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Investigation of fall protection for residential roof construction and repair in Hawaii

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INVESTIGATION OF FALL PROTECTION FOR

RESIDENTIAL ROOF CONSTRUCTION AND REPAIR IN HAWAII

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY
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By

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We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Civil Engineering.

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Next, the author acknowledges the assistance of the Roofers Union Local 221 and Carpenters Union Local 745. The Training Coordinators of both unions provided the author with the information necessary to understand labor's views in the ongoing debate over fall protection regulations in the residential construction industry. Additionally, they distributed and collected the worker surveys that were used in this research.

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Chapter 1: Introduction

1.1 Purpose

In February 1995, the United States Occupational Safety and Health Administration (OSHA) enacted revisions to the construction industry safety standards that regulate fall protection systems and procedures. Yet in 1995, falls accounted for 12% of all residential construction accidents in Hawaii (Hawaii, 1997a), and a failure to comply with these standards is one of the most frequently cited violations in inspections of residential construction sites (HIOSH, 1996). A majority of these falls and citations for lack of fall protection occurred during residential roof construction (HIOSH, 1996). Therefore, the Hawaii Occupational Safety and Health Division (HIOSH) funded this investigation of fall protection systems, behaviors, and attitudes in the area of residential construction. The purpose of this study is to investigate the conditions peculiar to residential roof construction in Hawaii, and to recommend actions to increase worker protection which meet the requirements of the various parties involved in Hawaii's residential roof construction industry.

1.2 Scope

The scope of this study is limited to residential roof construction in Hawaii, to include new construction, renovation, and maintenance of single-family residences, townhouses, and commercial buildings with residential-style (wooden or light-gauge steel truss and gable) roof systems. The study includes investigations of unique residences for individual homeowners, developments of single family homes and townhouses, and selected commercial sites. The study includes projects for private as well as public owners, including the United States Department of Defense.

1.3 Objectives

The objectives of this investigation are:

(1) Assess the current status of compliance with Hawaii state fall protection requirements.

(2) Analyze the sources of non-compliance with fall protection regulations in residential roof construction.

(3) Identify the fall protection requirements of the various parties involved in residential construction safety.

(4) Examine existing methods of fall protection for residential roof construction for their ability to meet those requirements.

(5) Incorporate the results of the investigation into specifications and other actions for HIOSH implementation.

1.4 Research Methodology

The investigation was undertaken in the following method, outlined in Figure 1.1 (following page):

(1) A comprehensive search of the literature on fall protection regulations, equipment, citations, behaviors, and attitudes was completed.

(2) Residential homebuilders, union representatives, fall protection equipment suppliers, roofing contractors, safety officers, and HIOSH personnel were interviewed for their concerns and ideas.

(3) Surveys were designed to obtain workers' views on fall protection.

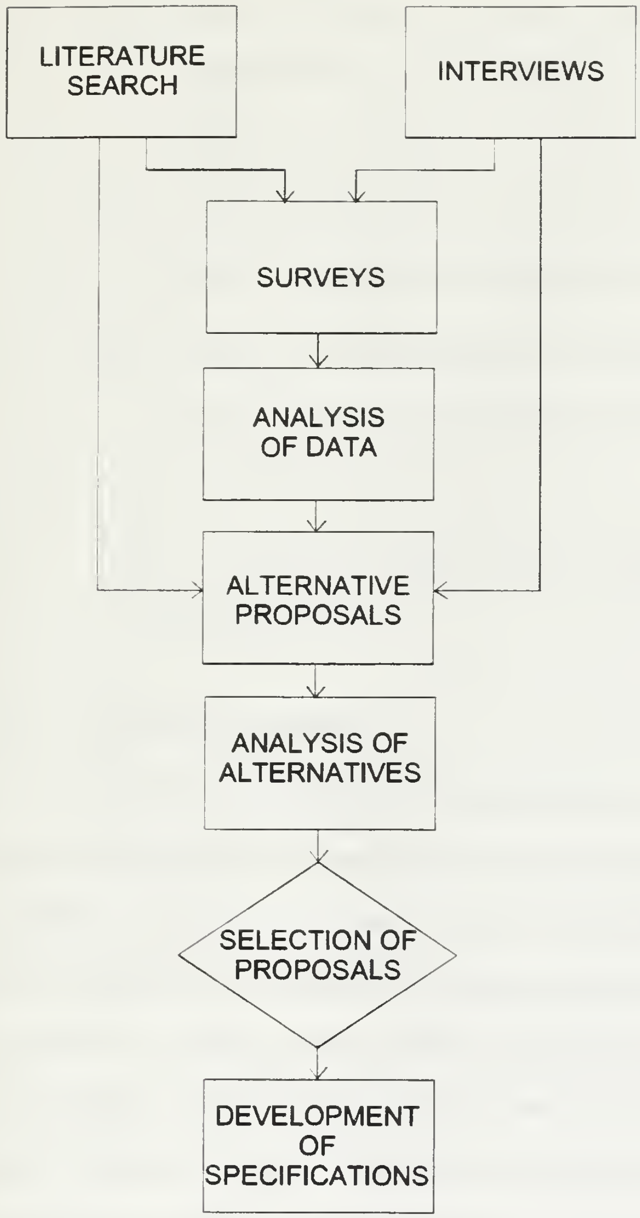

Figure 1.1: Research methodology

(4) The information gathered during the interviews and from the surveys was analyzed qualitatively and quantitatively using charts and statistical analysis methods. Observations were drawn from the results of the analysis.

(5) Alternative proposals were developed based on the ideas obtained through interviews, observations, and existing literature.

(6) The alternatives were analyzed for their ability to meet the concerns of contractors, labor, and enforcement, and the most effective alternatives were selected as proposals.

(7) Specifications and courses of action were developed for HIOSH based on these proposals.

1.5 Overview of the Report

The remainder of the report is organized into seven additional chapters. The second chapter discusses pertinent background information on fall protection regulations and systems. Chapter 3 summarizes the contractors' views, through analysis of the information obtained by interviews and field investigation. The fourth chapter presents labor's views, including an analysis of the workers' survey. Chapter 5 provides the regulatory agencies' requirements, found by investigation of case histories and interviews of enforcement and consultation officials. The sixth chapter presents the alternative proposals, and provides a cost/benefit analysis of those proposals. In Chapter 7, recommendations are presented and courses of action are proposed for implementation. Finally, Chapter 8 provides a summary of the investigation and presents recommendations for further study.

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Chapter 2: Background

2.1 Incidences and Impacts of Falls

It is recognized that falls are a severe problem in the construction industry, including the residential industry. This section will demonstrate the frequency of falls and the magnitude of the costs associated with falls in Hawaii's residential construction industry.

2.1.1 Construction Industry

Falls are the leading cause of occupational fatalities in the construction industry. In both 1994 and 1995, falls accounted for one-third of the fatal injuries to construction workers. Over 300 construction workers fall to their deaths each year. Almost one-fifth of those falls occur from roofs. Most of these falls are incurred by special-trade contractors, such as roofers and framers (Bureau of Labor Statistics (BLS), 1995a and 1996a).

Additionally, falls are one of the leading causes of nonfatal injuries to construction workers, accounting for over 10% of lost-time cases (BLS, 1995b). In 1993, nearly 42,000 disabling falls were reported in the construction industry. One in 100 construction workers sustained a disabling fall in that year. Each of those falls required an average of 14 days recuperation time. This is more than twice the recuperation time for falls sustained in other industries, indicating the particularly dangerous fall hazards found in the construction industry (BLS, 1996b).

Table 2.1 (following page) shows the distribution of fatal and nonfatal falls that occurred in the construction industry during 1993 (disabilities) and 1994 (fatalities). Falls from roofs accounted for more fatalities than any other type of fall. They were also the most severe type of disabling fall, requiring an average of 33 days away from work to recuperate (BLS, 1996b). Thus, it can be said that falls from roofs have a major impact on the construction industry.

Table 2.1: Fatal and disabling falls in the construction industry, 1993-94 (Source: BLS, 1996b)

Type of Fall	Percent distribution for: Fatal falls (n=330)[a]	Disabling falls (n=41,800)[b]	Median workdays lost from disabling falls[b]
All falls	100%	100%	14 days
Fall to lower level	96	57	17
Down stairs or steps	1	4	12
From floor, dock, or ground level	3	3	11
From ladder	14	20	15
From roof	32	7	33
From scaffold, staging	21	8	21
From building girder or other structural steel member	8	1	28
From nonmoving vehicle	3	6	11
Fall on same level	3	37	10
Other or unspecified	1	6	--

Notes:
[a] Based on data from the 1994 BLS Census of Fatal Occupational Injuries, which covered all construction workers--wage and salaried, self employed, and family members--in the private and public sectors.
[b] Based on data from the 1993 BLS Survey of Occupational Injuries and Illnesses, which covered just wage and salaried workers in private construction industries. Disabling falls are those that result in lost worktime. Median days away from work is the point at which half those cases involved more days and half involved fewer days. Dash indicates that a median was not computed.

2.1.2 Residential Construction

As in the general construction industry, falls are the leading cause of death in the residential construction industry, accounting for 33% of all occupational fatalities nationwide. Twenty-seven residential construction workers fell to their deaths in 1994. From a trade perspective, falls are the leading cause of death both for carpenters and roofers, accounting for 52% and 72% of fatalities, respectively (Toscano, et. al., 1996).

But is the frequency of falls--both fatal and nonfatal--more common in residential construction? The National Institute for Occupational Safety and Health (NIOSH) performed several analyses and comparisons of workers compensation claims in the residential construction industry to those in other sectors of the building construction industry. NIOSH found that "injured

residential construction workers had at least as high a proportion of their injuries due to falls from elevations as all other construction workers" (OSHA, 1994, p. 40694).

Of the 41 falls reported by Hawaii's residential construction industry in 1995, one resulted in death and 24 in temporary total disability. The total time lost for all 24 accidents was 1597 days, or an average of 67 days per fall, well above the nationwide construction industry average of 14 days per fall in 1994. This indicates that residential construction falls in Hawaii result in more serious injuries than do construction falls nationwide (Hawaii, 1997b).

2.1.3 Enforcement's Perspective of the Problem

From an enforcement perspective, since taking effect in February 1995, HIOSH has issued more citations for non-compliance with fall protection standards than for any other regulation. In fiscal year 1996 (October 1995 through September 1996), HIOSH issued 152 citations to residential contractors; 23 of those, or 15%, were related to a failure to provide adequate fall protection (OSHA, 1997).

Each of these citations drew an average penalty of $887, compared to an overall average of $497 for all construction citations (OSHA, 1997). The high incidence of citations indicates that there is a general lack of fall protection in the residential construction area. Likewise, the high fines demonstrate HIOSH's concern in this matter.

2.1.4 Economic Impacts

In Hawaii's residential construction industry, the total associated cost for all lost-time falls in 1995 was $341,395 (Hawaii, 1997b). The fines issued for violations of fall protection standards in FY96 totaled $50,752 (OSHA, 1997). Together, this equates to nearly $400,000 per year spent as a direct result of a lack of adequate fall protection in Hawaii's residential construction industry. This figure alone indicates that falls are a serious problem, and does not include the millions more associated with increased Workers' Compensation premiums as a result of those falls.

2.2 Fall Protection Regulations

This section will summarize OSHA's fall protection regulations for the residential construction industry, followed by a discussion of their development and their current status, both nationwide and in the state of Hawaii.

For the most part, fall protection regulations for the construction industry were consolidated in February 1995 into 29 CFR §1926.500 to §1926.503. Collectively, these paragraphs are referred to as Subpart M of the construction safety standards. Special construction circumstances, such as working from scaffolds or ladders, or structural steel erection, are not covered by Subpart M, but for general construction procedures, Subpart M gives the requirements for fall protection.

OSHA standards with fall protection requirements that were not superceded by the revised Subpart M are:

Subpart L - Scaffolds

Subpart N - Cranes and Derricks

Subpart R - Steel Erection

Subpart S - Tunnelling

Subpart V - Electric Transmission/Distribution Lines

Subpart X - Stairways and Ladders

The new Subpart M does not supercede the above standards when they have specific fall protection requirements. If there is something which occurs that is not addressed in the existing standard, then the new standard applies.

Subpart M is organized as follows:

§1926.500	Scope, application, and definitions
§1926.501	Duty to have fall protection (i.e., when, where, and how)
§1926.502	Fall protection systems criteria and practices (i.e., what is specifically required)
§1926.503	Training requirements
Appendix A	Determining roof widths; non-mandatory guidelines
Appendix B	Guardrail systems; non-mandatory guidelines
Appendix C	Personal fall arrest systems; non-mandatory guidelines
Appendix D	Positioning device systems; non-mandatory guidelines
Appendix E	Sample fall protection plans; non-mandatory guidelines

In addition to protection of workers from fall hazards, employers are now also required to train their employees in recognizing and protecting themselves from fall hazards. According to Subpart M, construction employers are required to take action to protect workers from fall hazards whenever they are exposed to a fall of six feet or more. More specifically, the new standard requires that fall protection be provided as shown in Figure 2.1 (following page).

For most situations in construction, Subpart M requires the use of positive fall protection measures, whether through the use of guardrails, safety nets, or personal fall arrest systems (PFAS). However, contractors involved in residential construction, and particularly residential roof construction, have the options of protecting workers via alternative measures, such as the fall protection plan, warning line, or safety monitoring system. Each of these methods will be discussed in more detail in sections 2.4 (conventional measures) and 2.5 (alternative measures).

- Must protect all workers on walking/working surfaces with unprotected sides or edges 6 ft or more above a lower level

- Limits options of fall protection to the following choices:

  (a) guardrail systems
  (b) safety net systems
  (c) personal fall arrest systems

- Holes & skylights: protection required for those with 6 ft or higher fall distance

- Ramps: protection required for those with 6 ft or higher fall distance

- Wall openings: protection required for those with 6 ft or higher fall distance

- Excavations: protection required for those with 6 ft or higher fall distance

- Overhand bricklaying will have a fourth option of using a controlled access zone, unless bricklayers must reach more than 10" below working surface, in which case (a), (b), or (c) must be used

- Low-sloped roofs (slopes less than or equal to 4 in 12) will have fourth option of warning line system used with safety monitor; fall height starts at 6 ft vice 16 ft

- Steep roofs (slopes greater than 4 in 12) will have only options (a), (b), or (c)

- Precast concrete erection has options of (a), (b), or (c); where infeasible, must implement a "fall protection plan"

- Leading edge work has options of (a), (b), or (c); where infeasible, must implement a "fall protection plan"

- Residential construction work has options of (a), (b), or (c); where infeasible, must implement a "fall protection plan"

- "Fall protection plan" must:

  (1) Be written specifically for the site
  (2) Document why (a), (b), and (c) are infeasible
  (3) Have written discussion of other measures that will be taken to reduce or eliminate the hazard
  (4) Identify each location where (a), (b), and/or (c) cannot be used
  (5) Incorporate, at minimum, a safety monitoring system
  (6) Incorporate a controlled access zone
  (7) Incorporate specific fall protection training for each worker exposed to falls
  (8) Require investigation of fall accidents and implementation of changes to prevent further occurrences

Figure 2.1: Highlights of Subpart M (Source: Highlights)

2.2.1 *Development of Subpart M*

In 1977, as part of its continuing evaluation program, OSHA began a review of the previous Subpart M, Floor and Wall Openings and Stairways. In November 1986, OSHA proposed to revise all fall protection standards and place them collectively in a new Subpart M. The rulemaking process began, and OSHA received 162 written comments on their proposal, including several requests for open hearings. In March 1988, informal public hearings were held. In August 1989, the rulemaking record was certified and closed, and OSHA began writing the new Subpart M based on the rulemaking. In August 1992, the record was reopened to consider new information submitted by the Precast/Prestressed Concrete Institute regarding the special considerations of workers engaged in precast concrete construction. The rulemaking record was closed in November 1992. In response to requests from the precast concrete industry to extend the rulemaking, OSHA reopened the rulemaking for the final time in March 1993. At this time, OSHA also requested comments on the special circumstances involved in residential construction. In May 1993, after receiving 28 comments, OSHA closed the rulemaking. The final rule was published in the *Federal Register*, volume 59, in August 1994, and took effect in February 1995 (OSHA, 1994, pp. 40672-73).

The focus in the development of Subpart M has been to use more performance-oriented criteria, wherever possible. Although certain parts of the regulations, notably §1926.502, are still largely specification-oriented, most parts have been changed to be much more performance-oriented, with the bottom-line criteria being the protection of the workers.

OSHA also has focused on requiring positive fall protection measures wherever feasible, but where the employer can prove that positive measures are either "infeasible" or would pose a "greater hazard," OSHA has allowed alternative, passive protection methods. "Infeasible" is defined as being "impossible to perform the construction work while using a conventional fall protection system, or that it is technologically impossible to use a conventional system" (OSHA, 1994, p. 40678). The employer is responsible for identifying the site-specific circumstances that

preclude the use of the conventional system. A "greater hazard" defense requires the employer to demonstrate that "the hazards created by compliance are greater than those created by non-compliance" (*Ibid.*, p. 40685).

OSHA continues by saying that "employers will need to reexamine their 'traditional methods' and, when possible, update them by incorporating available fall protection technology and design concepts" (*Ibid.*, p. 40680), and that "employers will not be permitted to gain a competitive advantage by exposing their workers to fall hazards" (*Ibid.*, p. 40681). In other words, OSHA does not believe that infeasibility or greater hazards exist at all worksites nor for the entire duration of the project's construction. Therefore, if the employer wishes to use alternative, passive fall protection measures, he/she must prove the infeasibility or greater hazard in that particular instance.

However, when discussing the exception for residential construction, §1926.501(b)(13), OSHA appears to relax its stance:

> OSHA does not expect employers (home builders) to pursue measures which would make their work unprofitable. For example, OSHA expects that there will be circumstances where a home builder will find it to be cost-effective to rent a crane for the purpose of hoisting roof trusses, particularly when several roofs can be set in a single day. Also, OSHA is aware . . . that there are a number of devices readily available for use as attachment points for fall arrest equipment and that employers must be able to document why the use of such equipment is infeasible or creates a greater hazard to meet the criteria for using a fall protection plan.
>
> On the other hand, the Agency believes it would be unreasonable to expect the home builder to rent a crane when the home site is difficult to access . . . or when the home builder has only a single roof to raise. In addition, OSHA does not expect home builders to erect scaffolds around the entire perimeter of a house, or to take other extremely burdensome measures . . . . These measures are infeasible. (OSHA, 1994, p. 40693)

Additionally, researchers at the University of Florida's Center for Construction Safety and Loss Prevention found that OSHA "does not plan to be real strict" in its enforcement of the infeasibility defense, with regard to the fall protection plan (Coble and Elliott, 1995, p. 8). Their interviews with OSHA's Chief of Construction Compliance Division indicated that OSHA considers

the requirements to develop a "custom plan" as equally difficult to implement and as equally effective in protecting workers as conventional fall protection systems (*Ibid.*, p. 7).

It appears, therefore, that OSHA is contradicting itself in its preamble to the final rule. First, OSHA asserts that infeasibility and greater hazards are uncommon, and will not be approved based on economic justification alone; later, OSHA states that certain economic justifications constitute infeasibility. This contradiction leaves many questions for the home builder to answer as he/she believes is appropriate, and not necessarily for the greater protection of the workers. OSHA itself recognizes that positive fall protection is more effective than passive measures, and finishes its discussion of §1926.501(b)(13) by stating, "The Agency considers the implementation of a fall protection plan . . . to be a 'last resort,' allowed only where the other options for fall protection have been exhausted" (*Ibid.*, p. 40695). However, OSHA is placed in the difficult situation of having to protect the worker's life while not putting the worker's employer out of business (Bielaski, 1997). Sometimes, compromise is necessary.

Subpart M, in its entirety, was adopted by the State of Hawaii in March 1995 in the Hawaii Administrative Rules (HAR) §12-121.2.

2.2.2 *Current Status of Subpart M*

Upon becoming effective in February 1995, Subpart M was immediately disputed by the home builders and roofers of the residential construction industry. Appealing to their legislators, they led a constituent uprising, primarily focused on the costs of compliance. In response, legislators began to examine the effectiveness of OSHA's rulemaking procedures. Assistant Secretary of Labor for Occupational Safety and Health, Joseph A. Dear, addressed the Committee on Small Business in June 1995. In his comments, he emphasized OSHA's commitment to worker safety, and to employer concerns as well: "OSHA has made every effort to respond to the concerns of the regulated community and to involve all interested parties in the development and implementation of this standard" (Dear, 1995).

In response to Congressional pressure, OSHA issued two memoranda relaxing their stance on residential fall protection requirements. The first was issued in July 1995 from the Deputy Assistant Secretary to the Regional Administrators, regarding the enforcement of fall protection plans. "To eliminate the need for contractors to repeatedly make the same arguments and demonstrations at each project site with regard to infeasibility or greater hazard, OSHA will accept the reasons provided in the sample fall protection plan as meeting the plan justification requirements of the standard. . . . In addition, fall protection plans need to be site specific only to the extent that they address the fall hazards present at that site" (Stanley, 1995).

The second memorandum, OSHA Instruction STD 3.1, was issued in December 1995 by the Directorate of Construction. Instruction STD 3.1 states that OSHA intends to reopen the rulemaking record for Subpart M to address the concerns of the residential construction industry. It also outlines interim fall protection compliance guidelines for residential construction. These guidelines allow contractors to implement alternative fall protection measures without addressing infeasibility or greater hazard concerns. In short, a fall protection plan is no longer required for residential construction, so long as "safe work practices," as outlined in Appendix E of the standard or in Instruction STD 3.1, are in effect (OSHA, 1995).

Since the issuance of Instruction STD 3.1, Congress has appropriated $2 million to OSHA for researching the practical impacts of regulations on the residential construction industry. The Advisory Committee on Construction Safety and Health (ACCSH) has established a Workgroup on Residential Construction, which has met several times to discuss the particular issues involved in residential construction safety, including fall protection. However, OSHA has yet to issue a Notice of Proposed Rulemaking (NPRM) in this matter, although one is expected to be released by late 1997 (Bielaski, 1997).

HIOSH has adopted an enforcement policy that allows the use of one fall protection plan to cover several sites, in congruence with the first OSHA memorandum. However, HIOSH has not adopted OSHA Instruction STD 3.1, and instead is requiring fall protection plans in order to

use alternative methods on residential construction sites, in accordance with HAR §12-121.2 (HIOSH, 1996).

2.2.3 Issues of the Debate Regarding the Implementation of Subpart M

The debate regarding the implementation of Subpart M involves three major factions--the contractors' faction, the labor faction, and the regulators' faction. Each faction has its own agenda, as described below. The resolution of the Subpart M conflict through a win-win-win solution can only occur if each of the issues is addressed and satisfied.

2.2.3.1 Contractors' Views

The contractors' agenda is profit-based. "We're in this business to make money," said an anonymous contractor's construction manager, when questioned why he did not share information on a procedure which was safer, and also more profitable, than conventional construction methods. "If we share the information with other contractors, we will lose our edge" (Construction Manager #1, 1997). The "competitive edge" is especially important in Hawaii's new home market, which seems to be saturated at this point.

"To be honest," said another construction manager, "safety takes time, and time costs money" (Construction Manager #2, 1996). Most construction managers interviewed felt the same way. "If we were to protect every worker from every fall hazard," lamented another manager, "it would add three days to the construction time for each home" (Construction Manager #3, 1997).

Other contractors felt that the regulations were not realistic. "There is no way to protect the workers while they install trusses," said another superintendent (Construction Manager #4, 1997). "What can you do to protect roofers when they've finished everything but the ridge?" asked a roofing contractor (Construction Manager #5, 1997).

Many of the contractors interviewed thought that the regulations were unnecessarily restrictive. "The residential construction industry is not as dangerous as the commercial building

industry," said one. "We have lower heights, and lighter building materials" (Construction Manager #3, 1997).

Yet another reason for noncompliance was the inability to get subcontractors and workers to follow the regulations. Every contractor interviewed believed that the workers themselves did not want to use safety harnesses, and the subcontractors did not want to purchase expensive guardrail or safety net systems. Each of these superintendents had to constantly warn their subcontractors of the consequences of noncompliance.

The primary issue, however, remains profit. "My roofing subcontractor is only clearing $235 per home, after labor and materials," said one superintendent. "The business is cutthroat" (Construction Manager #4, 1997).

2.2.3.2 Labor's Views

Unions were first organized at the turn of the century, to look out for the safety and welfare of workers. The union agenda, both at a national and a local level, is to protect both the worker's health and his/her job. Unfortunately, sometimes these two interests are conflicting.

In their review of Subpart M, the United Union of Roofers, Waterproofers and Allied Workers "urged OSHA to 'promulgate a standard that will effectively protect roofers against the dangers from fall hazards which they face almost daily.'" Contending that alternative measures, such as warning line systems, were ineffective, they pushed for "total perimeter protection" for roofers (OSHA, 1994, p. 40690).

The United Brotherhood of Carpenters, in their response to Subpart M, stated, "The fall protection safety requirements for residential construction should be the same as those for commercial construction. . . . The hazards in residential construction are every bit as real as those in commercial construction." They also argued that "conventional fall protection measures are feasible" (as quoted in OSHA, 1994, p. 40694).

However, since their initial reviews, both unions have modified their views somewhat, according to OSHA's Subpart M Project Officer. Although still concerned with protecting their members, when informed by contractors that their members would be out of a job if positive fall protection was required, they compromised their positions to some degree (Bielaski, 1997). The Roofers' Union modified its request for total perimeter protection starting at six feet, to protection starting at ten feet (Dear, 1995).

The local unions are also concerned about fall protection in residential construction. In Hawaii, most new residential construction is accomplished by union-shop contractors (Chong and Subiono, 1997, and Mactagone, 1997). Even these union-shop contractors aren't always concerned about the safety of their workers, but at least in the union shops, the workers have a shop steward advocate. Still, workers often won't report violations to the union or to OSHA. The workers appear to be more interested in job security than in personal safety (Mactagone, 1997).

The local unions feel that speed is a contributing factor to most unsafe behavior. "The pressure from the contractors is intense," said the Training Coordinator of Carpenters' Local 745, "and competition is keen" (Mactagone, 1997). "If the issue is production vs. protection," said the Training Coordinators of Roofers' Local 221, "production takes precedence" (Chong and Subiono, 1997).

2.2.3.3 Enforcement's Response

OSHA and HIOSH are placed squarely in the middle of the debate. Like the unions, their primary purpose is to protect workers from occupational hazards. However, they must take the economic consequences of their regulations into account when drafting changes. In developing Subpart M, the economic consequences were examined. "Compliance with the requirements of the revised Subpart M standard has been determined to be economically feasible and is not expected to produce any significant adverse economic impacts. . . . The estimated compliance

costs represent . . . less than 0.5 percent of revenues for each individual construction sector" (OSHA, 1994, p. 40725).

However, after issuing Subpart M, and being called to testify before Congress on the impacts of Subpart M, OSHA realized that it might not have placed enough emphasis on the competitive nature of the residential construction industry.

> Another issue that has come to our attention is the concern of many small contractors that they will be placed at a competitive disadvantage against other contractors who are not complying with the rule and who may escape OSHA enforcement. What some contractors may not realize is that OSHA does not have jurisdiction over sole proprietorships or other companies where no employer-employee relationship exists. Unfortunately, this may mean that there is not a level playing field between these different types of companies in the residential construction industry, so the concern is understandable. It is not, however, a valid reason to deny needed fall protection to millions of workers (Dear, 1995).

This statement underscores the competitiveness of the residential construction industry, especially in the single homeowner market.

To address these concerns, OSHA has issued the interim standard, and is currently conducting an in-depth study of the effects of its regulations on the residential construction industry. HIOSH is also concerned, but feels that the interim standard does not afford equal protection to the workers as Subpart M. Therefore, HIOSH has not implemented the interim standard, but has commissioned this study into the unique conditions faced by Hawaii's home builders in protecting their workers from fall hazards (HIOSH, 1996).

In summary, the issues in the Subpart M conflict include economic factors, feasibility of protection, behavioral factors (such as comfort and speed), and accident prevention. Each of these issues must be satisfied to successfully protect workers from fall hazards.

2.3 Sequence of Residential Roof Construction and Repair

Before discussing fall protection methods, the typical sequence of residential roof construction and repair will be presented to familiarize the reader with roof construction methods. The following information was gathered from site visits of new home developments and from interviews with architects, construction managers, and local union training coordinators.

2.3.1 New Construction

A typical construction schedule for the roof system of a new, two-story, single family home is shown in Figure 2.2 (following page). This sequence was utilized by 70% of the construction managers visited during the course of this investigation. The framing contractor will usually first construct the 2nd story exterior and interior frame walls to support the roof system. Next, a truss supplier will deliver and "load" the trusses on the house. Typically, the trusses are loaded in bundles spaced evenly across the top plates of the exterior wall system.

The trusses are then "rolled" into place by two framers. In Hawaii, it is very common for this phase of work to be performed from the "top plates" of the exterior frame walls. The top plates are the top portions of the frame wall--either one or two 2"x4" (nominal) pieces of lumber, or a C-section of light-gauge steel. Regardless of the material used, the top plate is typically about 3½" wide. Each framer climbs to the top plate of the exterior wall on his or her side of the home. Each framer bends down, balancing on the top plate, and picks up one end of the truss. The two framers choreograph their movements to ensure that the actions of one do not throw the other off balance. The framers proceed to walk along the top plate until they reach the point where the truss will be located, and then they set the truss down and nail it to the top plate with toe-nails. The trusses are then braced by spacers, placed between the trusses in three points--at the top plates of both exterior walls and at the peak. Placement of the spacers at the exterior walls is accomplished from the top plates; however, to place the spacers at the peaks requires one of the framers to shimmy up to the peak of the truss, brace himself or herself in the truss

Activity	Manpower Required	Days												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Frame 2nd story exterior walls[a]	2	■	■											
Frame 2nd story interior walls	2			■	■	■								
Load trusses	2						■							
Set & brace trusses	2							■	■	■				
Roof sheathing	2										■	■		
Fascia installation	1												■	
Roof loading	1												■	
Roof installation	2													■

Notes:

[a] Denotes 2nd story walls which are separate from the 1st story exterior wall system. There are places on a typical single family home where the exterior walls extend from the foundation to the roof system. Those walls are framed in with the 1st story exterior walls.

Figure 2.2: Typical construction schedule for building the roof system of a new home

webbing, and then nail in the spacer. Once the truss is braced, the framers walk back to the stack of trusses, get another, and do it again, all from the top plate. Photographs in Appendix A show the practice of installing and bracing the trusses.

Once the truss system is braced, the roof sheathing, consisting of sheets of plywood, can be installed. Sheathing is usually assigned to one or two framers. Typically, they will begin sheathing at the lower edges of the roof, and work their way up to the peak. The framer often works from the top plate of the end wall to place the first sheet of plywood and nail it into place. Then, he or she can work off a combination of the sheathing, top plate, truss webbing, and wall frames in order to sheath the remainder of the roof. Because the roof system may not be fully stable until the sheathing is in place, framers may or may not be using positive fall protection in this phase of work. If they are, it will usually be a personal fall arrest system, explained below.

Following roof sheathing, fascia can be installed at the eaves, and the eaves can also be closed in if desired by the builder. Fascia is typically made of a 2"x8" (nominal) 8 ft piece of lumber which is nailed to the exposed edges of the trusses. The framer typically balances from

the edges of the roof sheathing, bending over while installing the fascia to the external edges. In the eyes of the Training Coordinator of Carpenters' Local 745, fascia installation is the most dangerous phase of work for a framer (Mactagone, 1997). Sometimes, fascia is installed prior to roofing; at other times and by other builders, it is installed after. It depends on the builder's methods and preferences.

The roofing material is delivered and loaded on the sheathing by a roofing supply company. Then, working from the edge to the peak, one or two roofers lay out a waterproofing paper over the sheathing and nail it in place, followed by the roofing material (asphalt shingles, cedar shakes, clay tiles, etc.). Roofing application is typically finished in one day per home.

2.3.2 Repair

Roof repair can be further subdivided into renovation, meaning the removal of the entire roof system and replacement with a new one, or reroofing, meaning the removal of the previous roofing application and replacement with new roofing material only. For renovation, the phases involved include:

- Demolition - Removal of the existing roof system, to include roof sheathing and certain structural framing members, depending on the condition of the structure (e.g., termite infestation) and the scope of renovation (e.g., changing the slope of the roof to accommodate a new loft).
- Framing Reconstruction - If any structural framing members were removed, they must be replaced in the manner described for new home construction--walls, trusses, sheathing, and finally fascia.
- Roofing - As above, this involves roof loading and roof application.

For reroofing, demolition is limited to only that material needing to be removed due to excessive weathering or other damage. A limited amount of framing reconstruction may be required. Roof loading and application is accomplished as noted above.

2.4 Conventional Fall Protection Methods

This section will review the conventional, or positive, fall protection methods authorized by Subpart M: guardrails, safety nets, and personal fall arrest systems. It will detail how these methods are currently being used by Hawaii's residential roofing construction contractors, and will present their advantages and disadvantages. Additionally, it will outline the requirements of work positioning systems, and the differences between work positioning and fall protection.

2.4.1 Guardrails

Guardrails are governed by 29 CFR 1926.502(b). The top edge of a guardrail must be 42" +/- 3" above the working surface. An intermediate structure, consisting of midrails, intermediate vertical members, or screen, is required unless a parapet wall, 21" high, exists. If used, midrails must be positioned halfway between the top edge and the working surface. Intermediate vertical members, if used, must be spaced not more than 19" apart. Guardrail systems must be constructed of a smooth material and the railings must be at least ¼" in minimum dimension; banding is specifically prohibited from use. The top rail must withstand up to 200 pounds of vertical force and deflect to no lower than 39" above the working surface. Other structural members must withstand up to 150 pounds of force. Finally, if wire rope is used as a top rail, then it must be flagged at 6 ft intervals. (OSHA, 1994, pp. 40733-40734) Guardrails are authorized for use in all phases of residential construction, including roof construction, although toe boards are also required for guardrails used on steep roofs (slope > 4:12).

Although they have found little favor in Hawaii's residential roof construction industry, there are guardrail systems that are designed specifically for the concerns found in residential roof construction. One such system is the PR-20 Eave Catchguard System, shown in Appendix

A. This system was being used on an Oahu residential development, and a photograph of the system is shown in Appendix B. The only disadvantage of this system is that it requires about two hours for set-up. When "time is money," those two hours may decrease profitability.

Another guardrail system was in use during siding operations on an Oahu Navy family housing development. This system, a contractor-fabricated wooden guardrail system, could only be used following sheathing and prior to roofing, as it attached directly to the roof deck. A photograph of the system is shown in Appendix B.

2.4.2 Safety Nets

The regulations for safety nets are found in 29 CFR 1926.502(c). Safety nets should be placed as close as practicable under the working surface, but in no case more than 30 feet below it. The fall path from the working surface to the net must be unobstructed. The net must extend outward at least 8 ft from the edge of the working surface. If the fall distance is greater than 5 ft, the net's outer edge must extend further (5-10 ft drop = 10 ft extension, >10 ft drop = 13 ft extension). A drop test or certification procedure must be conducted on all safety nets following their construction, and they must be inspected weekly and after any occurrence which could affect the net's integrity. The net must also be cleared of any debris following each workshift. Finally, mesh openings in the net must be less than or equal to 6" on the longest side, and less than or equal to 36 square inches in area. (OSHA, 1994, p. 40734)

Although they are often used in commercial building, safety nets are not being used in the residential construction industry in Hawaii due to the small fall distances and the engineering requirements. As Steve Hanson, fall protection training instructor with Western Safety Associates, explained, "It is far easier to design fall prevention, like guardrails, than to design fall protection, such as safety nets." (Hanson, 1997)

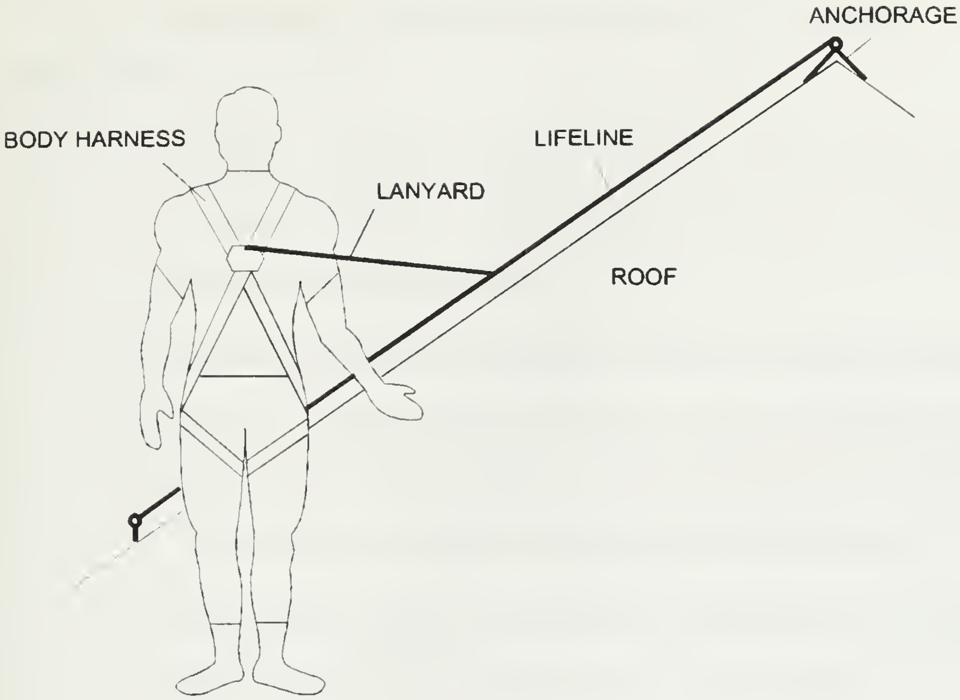

Figure 2.3: Components of a personal fall arrest system

2.4.3 Personal Fall Arrest Systems

The most frequently used form of fall protection in Hawaii's residential roof construction industry is the personal fall arrest system (PFAS). OSHA defines a PFAS as "a system used to arrest an employee in a fall from a working level, [consisting of] an anchorage, connectors, a body belt or body harness, and . . . a lanyard, deceleration device, lifeline, or suitable combination of these" (OSHA, 1994, p. 40679). In other words, a PFAS is the entire system used to protect an individual worker from falls. A schematic of the components of one such system is shown in Figure 2.3.

OSHA sets forth many requirements for PFAS in 29 CFR 1926.502(d); the major points are listed below:

- Anchorages: Must be able to sustain a minimum of 5000 pounds of force per employee attached, or be designed with a safety factor of 2 and placed under the supervision of a qualified person.
- Vertical lifelines: Must have a breaking strength which meets or exceeds 5000 pounds, unless free fall is limited to 2 ft or less, in which case minimum breaking strength is 3000 pounds. Only one worker allowed per line (except in certain cases of elevator shaft construction). Must be synthetic.
- Horizontal lifelines: Must be designed with a safety factor of 2 and installed under the supervision of a qualified person. Must be synthetic.
- Lanyards: Must have a breaking strength which meets or exceeds 5000 pounds, unless free fall is limited to 2 ft or less, in which case minimum breaking strength is 3000 pounds. Must be synthetic.

When stopping a fall, a PFAS must limit the maximum arresting force to 900 pounds, for a body belt system, or 1800 pounds, for a full body harness system. The free fall distance shall not exceed 6 ft, and the maximum deceleration distance allowed is 3.5 ft; however, in no case shall the fall victim be able to impact a lower level (OSHA, 1994, p. 40735).

The free fall and maximum arresting force requirements, however, can be contradictory; it is possible for a worker falling six feet to exceed an arresting force of 900 or 1800 pounds. Researchers at the University of Florida's Center for Construction Safety and Loss Prevention have found that these two requirements, in particular, have thus created "interpretation problems . . . . [because] this standard leaves room for individuals who are attempting to either comply with or enforce the standard to provide their own 'engineering' to determine how much free fall is allowed for a given employee using a particular PFAS" (Coble and Elliott, 1995, p. 8). Because

the standard doesn't provide engineering guidance, there have been problems in enforcing compliance. Per the researchers, OSHA is currently developing standards for such design methods (*Ibid.*).

PFAS are commonly used in several phases of residential roof construction, from sheathing to roofing and finish work. The primary advantage of a PFAS is its economy. The disadvantages include its restriction of mobility and difficulty of proper implementation. As Dr. J. Nigel Ellis, a noted fall protection expert, explains, "The typical philosophy has been to encourage workers exposed to hazards to tie off when stationary or when working. However, the choice is usually left up to the workers. . . . Many employers regard fall hazards as a necessary occupational hazard, and overlook them, depending instead on workers' practical ability" (Ellis, 1993, p. 24). Appendix B shows photographs of PFAS in use on various Oahu housing construction sites, and accents the difficulties of proper design.

2.4.4 Positioning Device Systems

Certain trades, such as reinforcing steel installers, use a system known as work positioning to keep them in place and prevent a fall while working on a vertical or near vertical surface. Work positioning systems are similar to fall protection systems in that they have the same components: an anchorage, connectors, body belt or body harness, and a combination of a lanyard, deceleration device, and/or lifeline(s). However, a positioning device system is defined by OSHA as "a body belt or body harness system rigged to allow an employee to be supported on an elevated vertical surface . . . and work with both hands free while leaning backwards" (OSHA, 1994, p. 40679).

When used, positioning device systems must limit free fall to 2 feet. Because of this, these systems typically require a different lanyard than the standard shock-absorbing lanyard used in most PFAS. The lanyards most commonly used are short, 2-3 ft lanyards or self-retracting lanyards. These self-retracting lanyards are similar to a seatbelt, in that they are under

constant, slight tension during normal work, and lock if the worker slips, trips, or falls. Since the locking mechanism typically engages within a very short distance, the free fall is limited to 2 feet.

Since the free fall is limited, the required strength of the anchorage is reduced to 3000 pounds, affording more opportunities for tie-off spots. The final difference between PFAS and positioning device systems is that positioning device systems may be attached to the body belt or harness on the individual's chest or hip, and not his/her back, as is required for fall protection systems (*Ibid.*, pp. 40735-40736). This affords the worker the opportunity to work relatively unimpeded, especially if he or she is constantly bending and moving. Positioning devices are not currently authorized for use in residential construction work; however, they could possibly be used in conjunction with an alternative fall protection method, as described below.

2.5 Alternative Fall Protection Methods

In the residential roof construction industry, HIOSH allows several forms of alternative fall protection; these are:

- Safety monitoring systems - A worker is designated as the monitor to watch his/her co-workers and warn them of hazards.
- Warning line systems - A flagged line marks the "unsafe area" 6 ft from the edge of the roof.
- Fall protection plans - The employer performs a comprehensive analysis of fall hazards to be found on the job, and delineates the exact method of preventing falls for each hazard.
- Roof jack systems - Also known as slide guards, roof jacks are planks that are placed perpendicular to the roof at the roof's edge to stop the slide of a falling person or object.

These alternative methods are not positive protection measures; that is, there is no device or guard that will either prevent a fall or protect the worker from the impact of the fall. The following sections will discuss in more detail each of the above alternatives, including the situations in which the alternative is permitted and the requirements of the alternative as described in Subpart M or HIOSH guidelines.

2.5.1 Safety Monitoring Systems

Safety monitoring systems involve the direct observation of workers by another individual, the safety monitor. The safety monitor must be a "competent person," meaning he/she must be "capable of identifying workplace hazards and have the authority to take prompt corrective action" (OSHA, 1994, p. 40715). The safety monitor observes all workers in the area, and warns them when it appears that they are unaware of a fall hazard or acting unsafely. He/she must be on the same working surface of the workers, within sight, and able to communicate orally. Finally, he/she can have no other responsibilities that could take his/her attention away from monitoring. (*Ibid.*, p. 40737)

For most operations, a contractor desiring to use an alternative form must demonstrate that using a positive form of protection, as described above, is infeasible or will result in a greater hazard to his/her employees. However, for low-sloped roofing applications (slope less than or equal to 4:12), a contractor does not need to demonstrate infeasibility nor greater hazard to use an alternative form of fall protection. In 29 CFR 1926.501(b)(10), OSHA permits the use of alternative forms of fall protection for low-sloped roofing applications. If the roof is less than 50 ft wide in its smallest dimension, as many homes are, roofers may use a safety monitoring system alone.

The advantages of the safety monitoring system include the lack of investment required for safety equipment. However, the loss in productive time for a worker to be set aside as the safety monitor may more than outweigh the cost advantage of equipment. Additionally, the safety

monitoring system is not a positive method of protecting the workers. Its effectiveness depends upon the monitor adequately observing and warning a co-worker, and the co-worker responding accordingly. Therefore, it is deemed to be the least effective method of protecting workers by OSHA (OSHA, 1995).

2.5.2 *Warning Line Systems*

Warning line systems consist of a flagged rope, wire, or chain, suspended 34"-39" above the working surface by stanchions and posts, placed at least 6 feet from the edge of the working surface. Workers within the warning line do not require any form of fall protection. Workers are only allowed outside the warning line if they are doing work in that area; once outside, workers must either use a positive form of fall protection (i.e., guardrail, safety net, or PFAS) or must be observed by a safety monitor as part of a safety monitoring system (OSHA, 1994, p. 40736).

Warning line systems are most often used in the commercial building industry. One warning line system was observed in use on a residential-type roof system that was part of a commercial building project. A warning line system is only allowed as a method of protecting workers engaged in roofing application, and only for low-sloped roofs (slope less than or equal to 4:12).

The main advantage of a warning line system is its low cost. Also, it is a passive system, which affords the worker some degree of protection without his or her involvement. However, it is not a positive method of fall protection, especially once the worker is outside the line. Still, if combined with a PFAS or some positive form of fall protection outside the line, this system can be extremely effective in preventing fall accidents.

2.5.3 Fall Protection Plans

Outlined in 29 CFR 1926.502(k), the fall protection plan is authorized for use in residential construction only when the contractor has shown infeasibility or greater hazard for positive fall protection. The fall protection plan must be prepared by a "qualified person," meaning an individual who "has successfully demonstrated his [or her] ability to solve or resolve problems relating to the subject matter, the work, or the project" (*Ibid.*, p. 40718). The plan must be implemented and supervised by a competent person. It should be site-specific, at least to the extent that it covers all fall hazards that exist on that particular job site. The fall protection plan should include the following (*Ibid.*, p. 40737):

- Situation-specific reasons why conventional systems are infeasible or create a greater hazard.
- Measures taken to reduce or eliminate the fall hazards for workers who cannot be protected using conventional fall protection systems; at a minimum, the measure will be a safety monitoring system.
- Each location in which conventional methods cannot be used; locations will be marked as controlled access zones (CAZ).
- Identification of individuals authorized in the CAZ, by name or other means. Other individuals will not be permitted in the CAZ.

In actuality, the fall protection plan is not, by itself, an alternative form of fall protection; instead, it outlines the use of other alternative forms of fall protection. In residential roof construction, these alternative forms can include a safety monitoring system, described above, or roof jacks, described below. Most often, however, the alternative methods outlined by a fall protection plan involve alternative work measures, such as those recommended by the National

Association of Home Builders (NAHB) for truss installation, found in non-mandatory Appendix E to Subpart M:

> On all walls eight feet or less, workers will install [sawhorse] scaffolds along the interior wall below the location where the trusses/ rafters will be erected. . . . All trusses/rafters will be adequately braced before any worker can use the truss/rafter as support. . . . The first two trusses will be set from ladders leaning on side walls . . . . A worker will climb onto the interior top plate via a ladder to secure the peaks of the first two trusses/rafters being set. . . . (OSHA, 1994, p. 40753)

The least protective alternative method allowed under a fall protection plan is the safety monitoring system.

Fall protection plans are in use throughout Hawaii's residential construction industry. Several fall protection plans were obtained from contractors, and are given in Appendix C. The primary advantage of the fall protection plan is its flexibility. If developed correctly, through a thorough examination of the construction process by a qualified person, the fall protection plan will likely result in changes to construction methods and the implementation of safe work practices that could eliminate or reduce fall hazards. However, in all likelihood, the plan is not developed in the manner outlined by OSHA in Subpart M. Instead, it is more likely that contractors have taken the example plans provided in Appendix E to Subpart M and have adapted them for their own needs. Many of the developers visited still use unsafe working practices like walking the top plate while installing trusses. Appendix B shows some photographs of standard work practices performed under a fall protection plan such as those in Appendix C.

2.5.4 Roof Jack Systems

OSHA's Instruction STD 3.1 allowed the use of a roof jack system for residential roofing applications. As described in Instruction STD 3.1, roof jacks are 2" x 6" nominal wooden planks that are positioned perpendicular to the roof's surface 2-3 feet from the rake edges of the roof, as shown in Figure 2.4 (following page). Roof jacks do not prevent falls on the same level, but could stop a falling object or person, thereby preventing falls to a lower level.

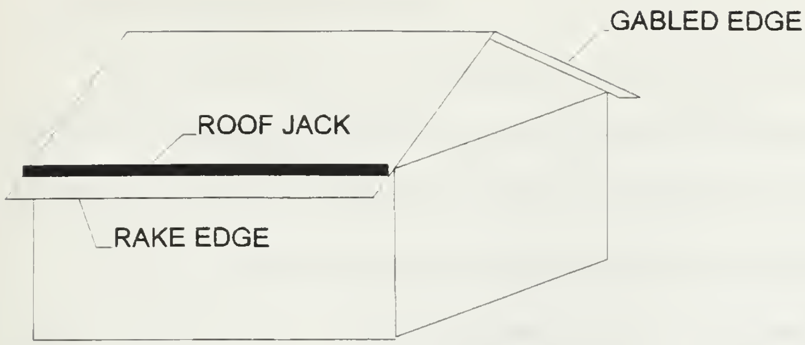

Figure 2.4: Roof jack system

Advantages of the roof jack system include its relative low cost and ease of installation. Like the other alternative methods, the roof jack system is not a 100% positive form of fall protection, and it does not prevent slips and trips on the same level. However, it should prevent most falls to lower levels from the rake edges of the roof. Also, because the jacks are not placed on the gabled edges, this system does not protect workers from falls off these sides of roofs (see Figure 2.4), nor through the roof, as during truss installation and roof sheathing. Finally, outside the roof jacks, the workers are unprotected.

Although Instruction STD 3.1 was not adopted by the State of Hawaii, HIOSH is currently in the process of developing a guideline that would permit the exclusive use of roof jacks alone for roof slopes up to and including 6:12. For roof slopes above 6:12, roof jacks would be used in conjunction with a positioning device system, as described in section 2.4. Due to the limited free fall distance and to the relatively large size of residential roofs, the positioning device system would typically require the use of a retractable lanyard to be feasible on residential roofing projects. For roof slopes above 6:12 and with an eave height exceeding 25 feet, roof jacks may be used, but only in conjunction with a conventional fall protection system (HIOSH, 1997a). The proposal is currently being reviewed by Roofers' Union Local 221 and the Hawaii Roofing Contractors' Association (Thorp, 1997).

2.6 Previous Research Conducted

As stated in Chapter 1, the first stage of research was to thoroughly investigate existing literature. This extensive literature search uncovered the following previous research into the areas of fall protection, residential construction, and/or roofing construction.

In 1975, NIOSH contracted a study on the particular hazards found in the roofing industry. The report took a behavioral approach, and involved extensive interviews and site visits of both commercial and residential roofing construction methods. The authors found that roofers took needless risks at many of the job sites they visited, including failing to cover roof openings. In surveys of roofers, they found that most roofers believed the key to improving safety was to resolve the conflict between productivity and safety. The authors proposed that such behavior issues were less likely to be resolved by enforcement than through the use of mandatory job training and certification of job competence with respect to safety issues (NIOSH, 1975).

In 1984, BLS published a comprehensive study of 77 occupational falls from elevations. The data showed that 17% of the falls occurred from scaffolds, 14% from roofs, and the remainder from other elevated surfaces. Nearly half of the injured workers did not consider fall protection to be practical, 20% felt that it was unnecessary, and 14% stated that it wasn't required. Almost half of the companies employing these workers did not require the use of fall protection equipment, and 75% had not conducted training (BLS, 1984).

Dr. J. Nigel Ellis first wrote his *Introduction to Fall Protection* in 1986, to introduce construction and industry safety managers to the concepts involved in preventing employee falls from elevation. Although he does not present his research methodology in his book, Dr. Ellis does present some of his findings, including the following:

- The frequency of falls is low. "Statistically averaged, there should not be a fall incident over one's supervisory career." (Ellis, 1993, p. 55)

- The intensity of falls is high. "Falls are the major cause of losses [from occupational injuries]." (*Ibid.*, p. 21)

- A comprehensive fall protection program can greatly reduce the economic impact of fall accidents. "Construction projects can benefit from an average of 35% bare labor savings [both time lost and productivity lost] when a 100% fall policy is adopted and applied." (*Ibid.*, p. 17)

Dr. Ellis also presents a hierarchy of fall protection, explaining that protection of workers from fall hazards is a four-tiered process. First, the task should be analyzed for the fall hazards to which workers will be exposed. If possible, the task should be modified to *eliminate* the fall hazard. If elimination is not possible, the fall itself should be *prevented* by measures such as guardrails. If prevention is not possible, the worker must use fall *arrest*. Fall arrest, while not preventing the actual fall, prevents or reduces the impact of the fall on the worker. Finally, the least protective method of fall protection is through *warning* the worker of the hazard, and monitoring him or her for unsafe behavior. The hierarchy for protecting workers from fall hazards, then, starts with elimination, moves on to prevention, then arrest, and finally warning. A responsible employer will go through each step, and try to protect his or her workers at the earliest stage (*Ibid.*, p. 68).

In 1990, NIOSH issued an "Alert," asking for assistance in preventing worker falls through roof openings (NIOSH, 1990). In response, Bobick, Stanevich, Pizatella, Keane, and Smith presented an "injury reduction matrix" which delineates responsibilities for controlling fall hazards to the various construction parties and throughout the various life-cycle phases of a building (Bobick, et. al., 1994).

At the 1991 annual conference of the American Society of Civil Engineers' (ASCE) Construction Congress, a paper was presented which reviewed the performance of various fall protection systems in use at the time. The authors compared the performance of "active" and "passive" protection systems, where an active system is defined as one which actively contains

workers from falling off the working surface, and a passive system is one which "catches" a worker after the fall. In other words, the authors compare guardrails and/or safety harnesses to safety nets and/or "sidewalk bridges." The authors present several interesting variations of fall protection systems found in other countries. They conclude that active and passive systems can both be used effectively, but that a rigid passive system (such as a "sidewalk bridge") is not as effective as a flexible passive system (like a safety net) in absorbing the energy of a falling worker or object, and therefore should be avoided as a sole measure of fall protection (Duncan and Bennett, 1991).

In 1995, several authors published the results of a contracted study for NIOSH called "SAFETY FIRST." This study involved the development of an expert computer system for construction falls. Several papers were published as a result of this study, including one focused on falls from scaffolds (Vargas, et. al., 1996a) and one from floor openings and edges (Vargas, et. al., 1996b). The project involved the use of fault-tree models for analyzing the potential cause(s) of a fall accident. The authors propose that there are two main types of causes of fall accidents--basic causes, which are "primary faults or failures which [can] lead to the occurrence of a fall," (*Ibid.*, p. 304) and conditioning causes, which are "problems or conditions in the system that, if combined with primary causes, enable the occurrence of a fall accident" (*Ibid.*, p. 306). These causes can be further subdivided as shown in Figure 2.5 (following page).

The authors suggest that guardrails, safety nets, and PFAS--the positive fall protection measures--can be inadequate due to either inadequate erection (e.g., missing components, poor installation) or inadequate materials (e.g., insufficient strength, excessive deflection, etc.). The authors also analyzed two passive measures: the warning line system and the controlled access zone (CAZ), and proposed that they could be inadequate if the warning line/control line were placed too close to the edge, or if it were placed too high/too low, so as to not be a useful warning. However, the authors did not analyze any of the other passive protection measures allowed by Subpart M (Vargas, et. al., 1996b).

- Causes of Falls
  - Basic Causes (Primary causes)
    - Enabling Causes
      Generated internal to the worker
      - Health problems
        (acute or chronic, incl effect of meds)
      - Attitude problems
        (e g , drug abuse, personality problems)
      - Skill problems
        (lack of training, lack of experience, or low aptitude for learning)
    - Triggering Causes
      Generated external to the worker
      - Impact-related
        (either by direct impact or by rendering unconscious or through attempts to avoid object)
      - Environmental-related
        (weather-related, heat, dust)
      - Distraction-related
        (anything which distracts worker from task at hand)
    - Support-Related Causes
      Related to working surface
      - Structural failure
      - Conditions of working surface
        (e g., littered with debris, wet from rain, etc.)
  - Conditioning Causes (Secondary causes)
    - General Safety Measures
      - Poor housekeeping
      - Inadequate overhead protection
    - Fall Protection/Prevention Safety Measures
      - Absence of measures
      - Inadequate measures
        - Inadequate erection
        - Inadequate materials

Figure 2.5: Causes of falls (adapted from Vargas, et. al., 1996b)

In 1996, at the first International Conference on Safety and Health in Construction, Hanna, Isidore, and Kammel presented a safety evaluation of the residential framing industry through a survey of framing contractors. They found that roof construction was considered by the framing contractors to be the most hazardous phase of frame construction. Additionally, the framing contractors surveyed said that falls were the third most common form of accidents suffered by their employees, behind foreign body penetration and struck by object. In order to reduce injuries, the authors proposed that OSHA regulations be followed and that mechanical equipment such as lift trucks used wherever possible (Hanna, et. al., 1996).

In summary, there have been several studies and investigations which can be related to the topic of fall protection in the residential construction industry; however, none have specifically focused in the area of fall protection for residential roof construction.

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Chapter 3: Contractors' Views

3.1 Methodology of Investigation

Following the literature review, the next stage of the research was to investigate the issues and interests of the various parties. The interests and issues of each party must be thoroughly examined in order to develop a solution that is satisfactory to all parties. These interests and issues can be found through comprehensive investigations involving interviews, surveys, and inspections.

The first party so examined were the contractors who comprise the residential construction industry. This investigation involved two sub-steps:

(1) Interviews of construction managers

(2) Inspections of job sites

The methods undertaken for each of these steps will be reviewed below.

3.1.1 Interviews of Construction Managers

Twenty-one interviews were conducted. Interviews were initially obtained with the assistance of the Builders' Industry Association (BIA), Hawaii. Additional references were obtained from the interviewees themselves, the Hawaii Roofing Contractors' Association (HRCA), the Naval Facilities Engineering Command, Pacific Division (PACDIV), and the 15th Civil Engineer Support Squadron, Hickam Air Force Base. The construction managers included representatives of developers, roofers, general contractors, owners, framers, and others, as shown in Figure 3.1 (following page).

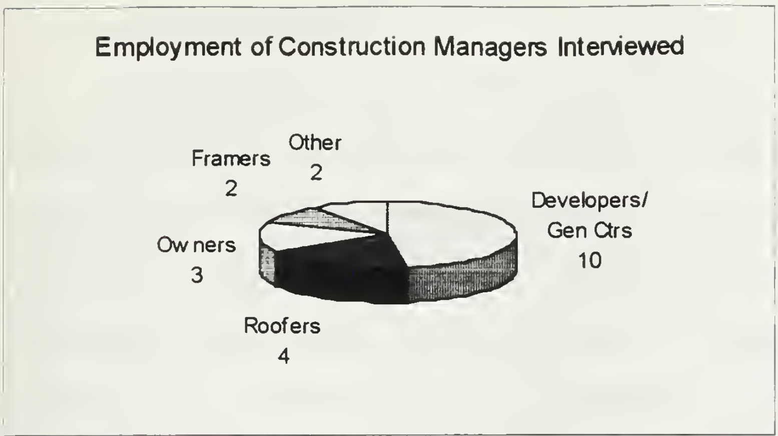

Figure 3.1: Composition of construction manager interview pool

The interviews were conducted in the offices of the construction managers, and involved a free-flowing discussion between the researcher and the manager. Each interviewee was asked several core questions at some point in the interview. These questions were:

(1) How compelled do you currently feel to comply with the existing fall protection regulations?

(2) What methods of fall protection have you used and how? Which method do you feel is most appropriate for each stage of roof construction?

(3) At what roof slope do you feel positive fall protection is needed?

(4) How frequently do you encounter problems which make it difficult for you to comply with the existing regulations? How would you characterize these problems?

(5) How would you regard your workers' level of compliance? Your supervisors'—including subcontractors'—level of enforcement?

(6) Why do your workers use positive fall protection? Why don't they?

(7) What could be done to increase worker protection while reducing current compliance problems?

3.1.2 Inspections of Job Sites

Typically, job site inspections were conducted in conjunction with interviews of the construction managers. Sixteen job sites were visited, in various stages of construction. These job sites involved large developments, either privately owned or military family developments, and single homes, all privately owned. Table 3.1 (following page) shows the characteristics of each site visited—ownership (public or private), number of units (single or multiple), type of construction (new, renovation, or reroofing), the stage of roof construction at time of inspection, and the type of roof being constructed (slope and material).

Each job site was inspected for its level of compliance with regulations and with site fall protection plans. A check-off sheet, as shown in Figure 3.2 (page 44), was utilized to guide the researcher during the site inspection. Where permitted, photographs were taken of any fall protection methods being employed and of workers observed both in compliance and not in compliance. Photographs are included in Appendix B. Sample fall protection plans are included in Appendix C.

3.2 Interviews with Construction Managers

The data found during the interviews were analyzed qualitatively. Notes from the interviews were first transposed into field reports, which were organized along the seven core questions given in section 3.1.1, above. Additional information was also recorded on the field reports. A database was developed to store, sort, and analyze the information obtained. The data, given in Appendix D, were analyzed using charts and statistics, as described below.

Table 3.1: Summary of job site inspections

Site #	Ownership	Number and Type of Units	Type of Construction	Stage of Roof Construction	Type of Roof
1	Private	Multiple single-family homes	New construction	Sheathing and roofing application	8:12, asphalt shingles
2	Private	Multiple condominium units	New construction	Complete	4:12, asphalt shingles
3	Private	Multiple single-family homes	New construction	Framing to roofing application	4:12, asphalt shingles
4	Private	Multiple single-family homes	New construction	Complete	5:12, fiber cement tiles
5	Private	Multiple single-family homes	New construction	Framing and sheathing	5:12, asphalt shingles
6	Private	Multiple single-family homes	New construction	Complete	5:12, asphalt shingles
7	Public	N/A[a]	New construction	Sheathing	4:12, metal
8	Private	Multiple single-family homes	New construction	Framing to roofing application	4:12, asphalt shingles
9	Private	One single-family home	Renovation	Roofing application (reroofing)	4:12, asphalt shingles
10	Private	One single-family home	Renovation	Complete	6:12, asphalt shingles
11	Private	One single-family home	Renovation	Complete	12:12, asphalt shingles
12	Public	N/A[b]	New construction	Roofing application	5:12, asphalt shingles
13	Private	One single-family home	Partial reroofing	Roofing application	4:12, cedar shakes
14	Public	Multiple single-family homes	Renovation	Framing to roofing application	4:12, asphalt shingles
15	Public	Multiple townhouses	Reroofing	Sheathing and roofing application	4:12, asphalt shingles
16	Public	Multiple townhouses	New construction	Framing to roofing application	5:12, asphalt shingles

Notes:

[a] Multiple commercial buildings with residential-style roofs (school)

[b] Single commercial building with residential-style roof (childcare center)

Job Site Inspection Sheet

Date of inspection: ______________ Location: ________________________

Ownership: PRIVATE PUBLIC

Type of construction: NEW RENOVATION REROOFING

Number of units: ONE MULTIPLE

Type of units: SINGLE-FAMILY HOME TOWNHOME CONDOMINIUM UNITS COMMERCIAL BUILDING/RESIDENTIAL ROOF

Stage of roof construction: FRAMING SHEATHING ROOFING COMPLETE

Type of roof:

Slope: ____:12

Material: ASPHALT CEDAR TILE METAL OTHER

Shape: GABLE HIP

Overall Compliance:

	Not Observed	Never	Seldom	Some-what	Mostly	Always
Supervisory enforcement level						
Worker compliance level						

Methods Used:

PFAS: ____

____

Guardrails: ____

____

Scaffolds: ____

____

Fall protection plans: ____

____

Other: ____

____

Photographs: ____

____

Figure 3.2: Job site inspection sheet

3.2.1 State of Compliance

Figure 3.3 shows the construction managers' responses to the first core question: How compelled to you feel to comply with regulations? Of the twenty-one interviewees, 57% (n=12) felt compelled to comply, while 43% (n=9) felt compelled not to comply. Of those who felt compelled to comply, the primary reason stated for compliance was enforcement by HIOSH. Of those who felt compelled not to comply, the principle reason for non-compliance was the competitive advantage it offered. This indicates that many construction managers perceive that the costs of current fall protection methods exceed their benefits.

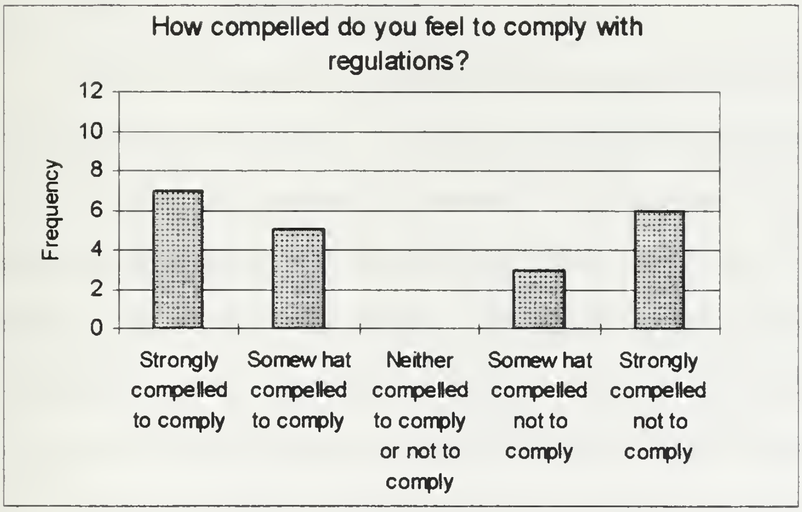

Figure 3.3: Construction managers' views on current regulatory state

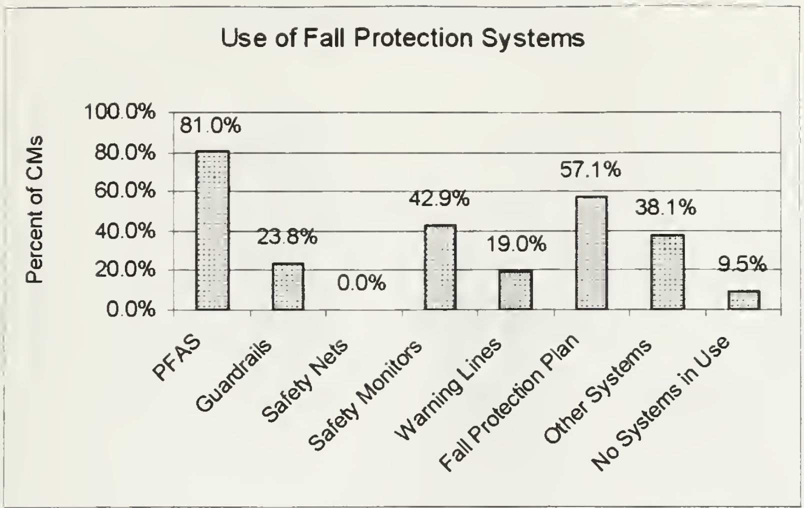

Figure 3.4: Fall protection systems in use in Hawaii's residential construction industry, as reported by construction managers

3.2.2 Use of Fall Protection Systems

Figures 3.4 through 3.11 all deal with the current use of fall protection systems in Hawaii's homebuilding industry. Construction managers were first asked which systems they had employed or had seen employed on residential roof construction. Figure 3.4 shows that construction managers most frequently employ PFAS, with 81% (n=17) having employed this system on one or more of their job sites. The second most frequently employed system is the fall protection plan. Over half (n=12) of construction managers had employed a fall protection plan on one or more of their job sites. The remaining fall protection systems, including guardrails, safety nets, safety monitors, warning lines, and other types of systems such as roof jacks, were each used by less than half of construction managers. Safety nets were not used at all by the construction managers interviewed. Incredibly, two of the construction managers indicated that they had not seen nor employed any fall protection systems on residential projects. The responses to this question indicate that Hawaii's residential construction managers employ a wide variety of systems to protect their workers from falls during roof construction, but most frequently

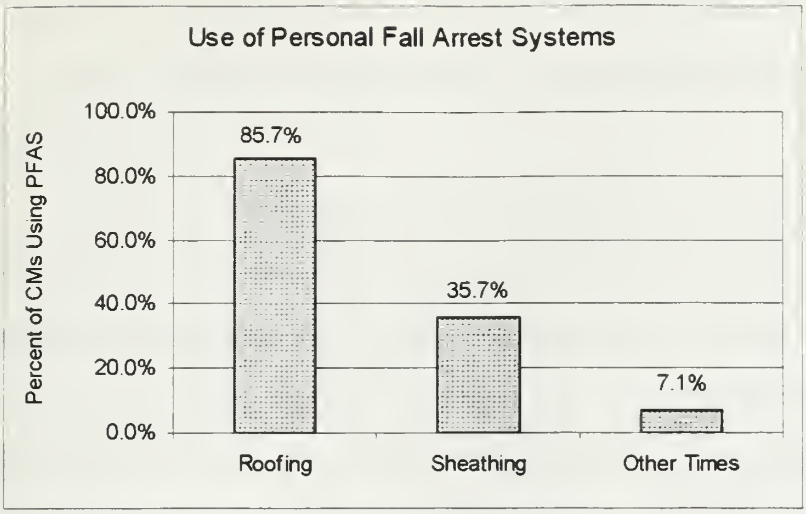

Figure 3.5: Use of personal fall arrest systems, as reported by construction managers

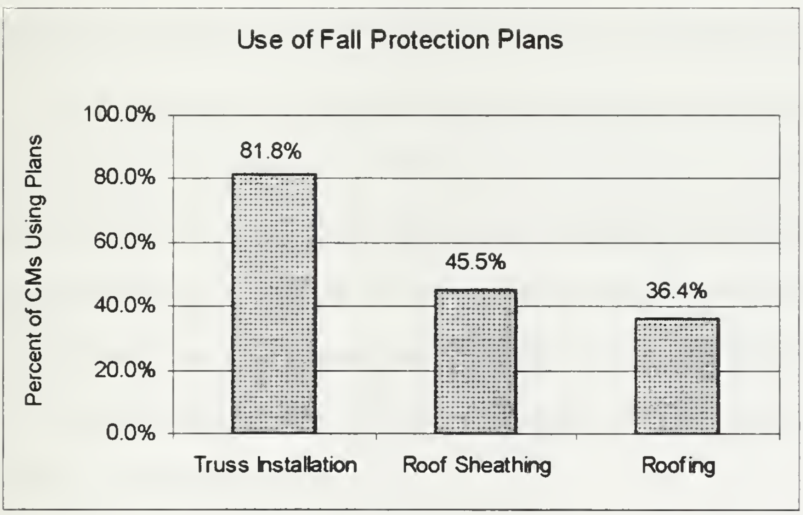

Figure 3.6: Use of fall protection plans, as reported by construction managers

employ PFAS and fall protection plans. The two construction managers who indicated that they never employed fall protection were involved in renovation and/or repair of privately-owned single-family homes.

Figures 3.5 and 3.6 (preceding page) show how construction managers utilize the two most common forms of fall protection systems--PFAS and fall protection plans, respectively. PFAS are most commonly used during roof application, but may also be used during roof sheathing and when doing finish work or other roof work, as shown in Figure 3.5. Fall protection plans, on the other hand, are more commonly used during truss installation. This indicates that construction managers feel there is an appropriate use for each type of fall protection system.

Figures 3.7 through 3.11 (pages 49-51) show the construction managers' responses to targeted questions regarding which form of fall protection was most appropriate for each phase of roof construction. The phases discussed included truss installation, roof sheathing, and roofing application, at slopes of less than 4:12, 4:12 to 8:12, and greater than 8:12.

The results reinforce the findings that construction managers feel there is an appropriate use for fall protection plans and for PFAS. As shown in Figure 3.7 (following page), fall protection plans were felt to be the most appropriate form of fall protection during truss installation. Figure 3.8 (also following page) shows that construction managers are split between preferring fall protection plans and PFAS during roof sheathing. The respondents with no opinion in Figures 3.7 and 3.8 were primarily roofing contractors and representatives, who are not involved in truss installation and roof sheathing.

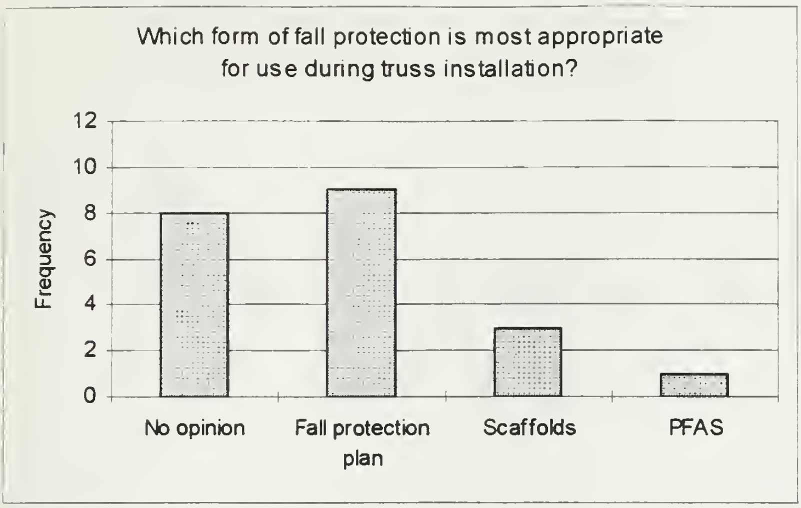

Figure 3.7: Appropriate fall protection for truss installation, as reported by construction managers

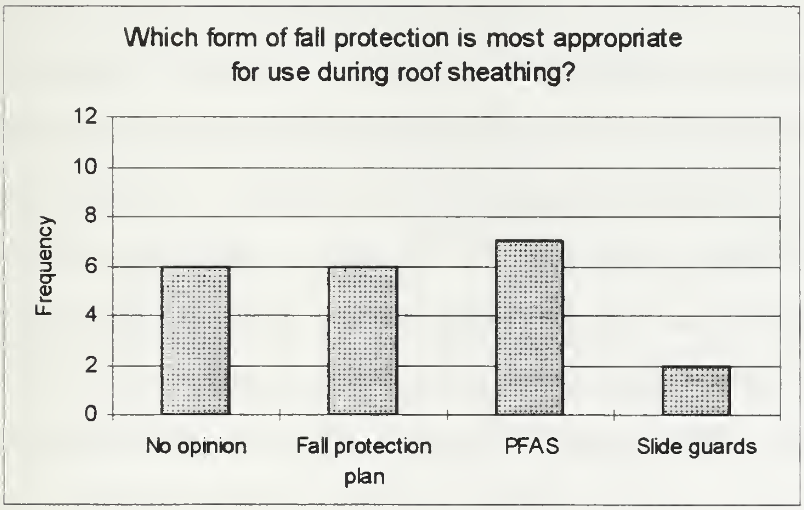

Figure 3.8: Appropriate fall protection for roof sheathing, as reported by construction managers

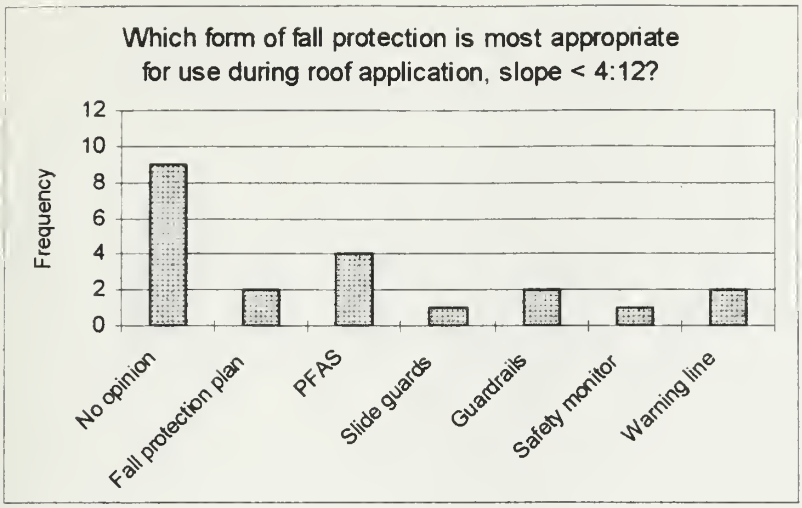

Figure 3.9: Appropriate fall protection for roofing application, slope < 4:12, as reported by construction managers

Figures 3.9 through 3.11 (above and following page) show the roofing contractors' preferences for fall protection. These responses are more divergent, including more options than the responses for truss installation and sheathing. The options narrow, however, as the roof slope increases. In Figure 3.9, for roofs with slopes below 4:12, the managers identified many different forms of fall protection; however, the PFAS remained the most preferred method of protecting workers. In Figure 3.10, for roofs between 4:12 and 8:12, the options narrowed, with the safety monitor option no longer cited as a most preferred method. Again, the PFAS remained the most preferred method. Figure 3.11 shows the responses for roofs with slopes above 8:12. At this point, guardrails and warning lines are no longer preferred by any respondents, and the principal method of protecting workers is overwhelmingly the PFAS. The respondents with no opinion for Figures 3.9 through 3.11 were framing contractors and other managers who were not familiar with roofing application.

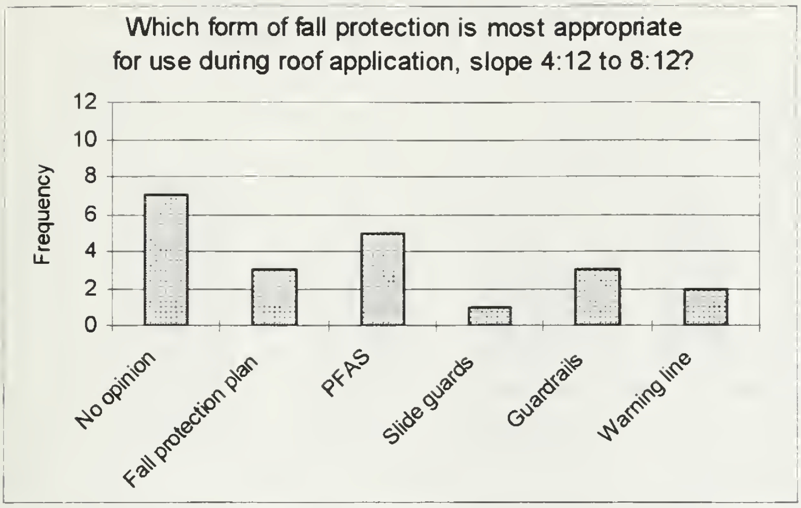

Figure 3.10: Appropriate fall protection for roofing application, slope 4:12 to 8:12, as reported by construction managers

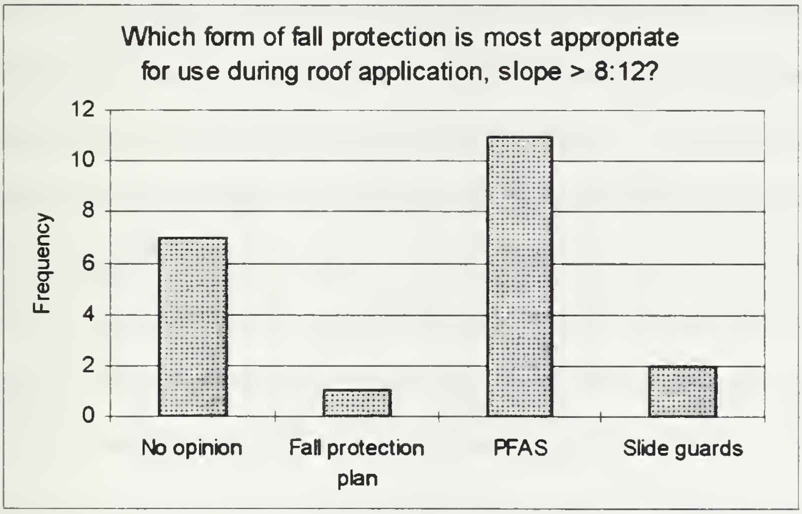

Figure 3.11: Appropriate fall protection for roofing application, slope > 8:12, as reported by construction managers

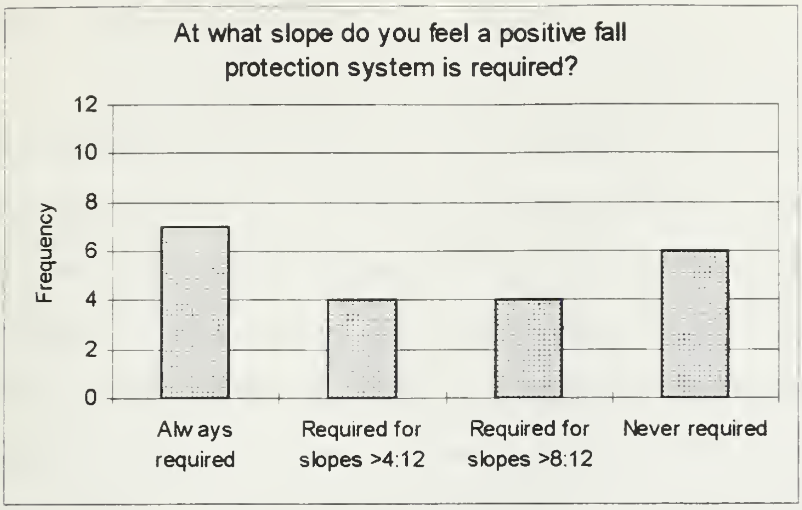

Figure 3.12: Necessity for positive fall protection, as reported by construction managers

3.2.3 Necessity for Positive Fall Protection

The next core question in the interview was, "At what slope do you feel positive fall protection is required during roof construction?" Figure 3.12 shows the frequency of responses for this question. Seven respondents believed that positive fall protection was always required, but six respondents believed that it was never required. Four felt that it was necessary at slopes above 4:12, and another four felt it was unnecessary until the slope exceeds 8:12. This supports the findings for appropriate use of fall protection systems identified in Figures 3.9 through 3.11. As the slope increased, the preferred systems became more positive and less passive. Even so, many construction managers did not feel that positive fall protection systems were ever required during residential roof construction, regardless of the roof slope. These managers felt that the alternative, passive forms of protection were more advantageous at all times.

3.2.4 Problems Encountered with Compliance

The next core question of the interview asked the construction manager how frequently he or she encountered problems that made it difficult for him or her to comply with the regulations, and also how he or she would characterize these problems. Figures 3.13 and 3.14 (following page) show the interviewees' responses. Over half (n=12) of the construction managers felt that they encountered problems frequently or all of the time, making it difficult to comply with the regulations. Another three felt they sometimes encountered problems. Four seldom encountered problems, while two stated that they never had any problems complying with the regulations. The relatively high frequency of non-compliance indicates that the current regulations may be misunderstood and/or misinterpreted. It also indicates that the current regulations do not satisfy the concerns of Hawaii's residential construction contractors.

Of the nineteen respondents who had encountered problems with compliance, almost 80% (n=15) of them believed that worker behavior was a significant problem, as shown in Figure 3.14. The next most frequently cited problem was cost-related, with almost half (n=9) of the respondents citing it. The impact on productivity was given as a problem by 42% (n=8) of the respondents. Another eight respondents believed that the design of the homes did not allow for the proper use of fall protection systems, while 26% (n=5) looked to themselves and believed that construction methods did not allow for their proper use. Over a quarter (n=5) believed that subcontractor behavior was a significant source of non-compliance. Ten percent (n=2) stated that there was a lack of training in fall protection, and another ten percent believed there to be a lack of knowledge in the regulations. The character of non-compliance, then, is one that involves all the players in the residential construction industry, including the architect, the developer, the general contractor, the subcontractor, the union, and the individual worker.

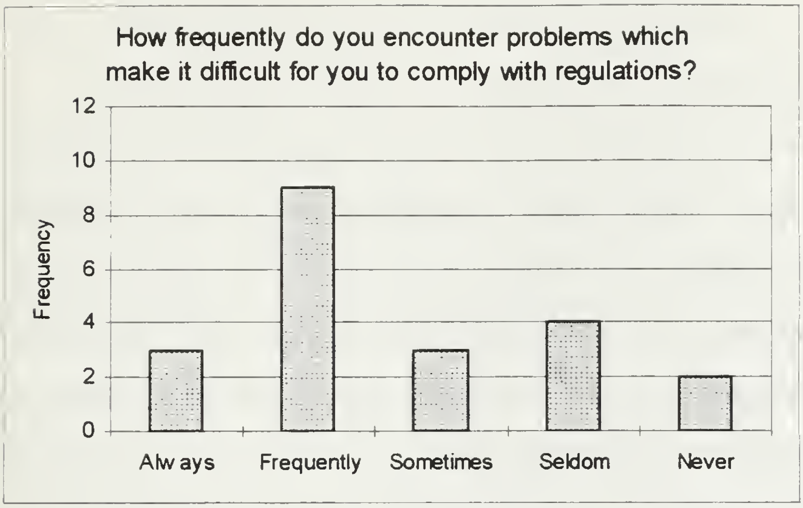

Figure 3.13: Frequency of non-compliance, as reported by construction managers

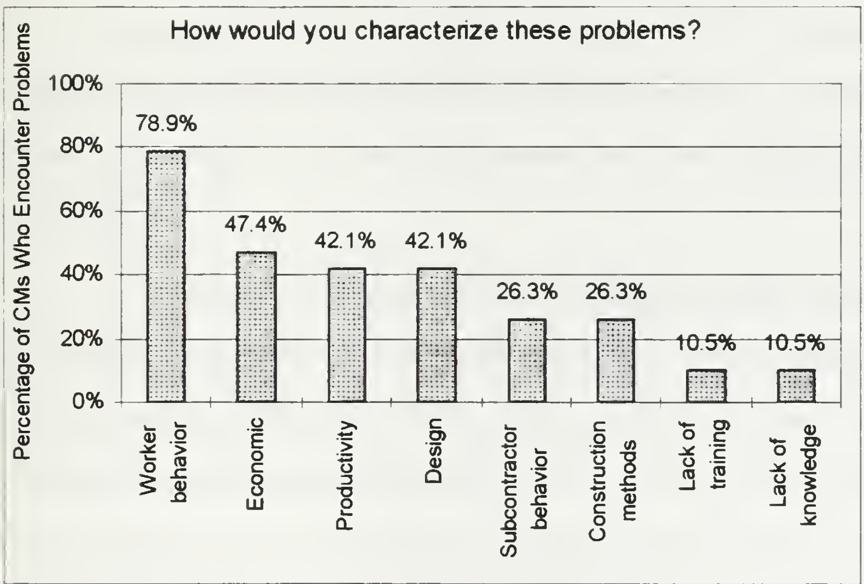

Figure 3.14: Sources of non-compliance, as reported by construction managers

3.2.5 Worker Compliance and Supervisor Enforcement Levels

Core question #5 asked the construction managers how they would characterize their workers' level of compliance with fall protection regulations, and their supervisors' level of enforcement of the regulations. Figures 3.15 and 3.16 (following page) show the construction managers' frequency of responses. Interestingly, over one-third (n=8) of the managers felt that their workers mostly complied with the regulations. These eight included four of the fifteen managers who stated that worker behavior was one of their major problems with compliance. Nearly 20% of the managers (n=4), therefore, felt that worker compliance was a problem, but then believed that their own workers were complying with regulations most of the time. This indicates that these managers may be too quick to blame the workers for non-compliance, and too quick to rule out other options. They are deceiving themselves by stating that the problem lies with the workers, when they themselves believe their workers comply, for the most part.

Over 40% (n=9) of the managers, however, felt that their workers seldom or never complied with regulations, including six of the fifteen managers who cited worker behavior as a problem with compliance. None of the managers interviewed felt their workers always complied with regulations.

As far as supervisory enforcement, the managers were almost evenly split between those who felt their supervisors and/or subcontractors usually enforced regulations and those who felt their supervisors seldom or never enforced them, as shown in Figure 3.16. The five respondents who had indicated that subcontractor behavior was a source of non-compliance split when it came to this question. Three of them indicated that their supervisors and subcontractors mostly enforced regulations, while two of them said that they seldom enforced regulations. Again, the three managers who felt that subcontractor behavior was a problem, but also that their supervisors and subcontractors enforced regulations most of the time, appear to be contradicting themselves.

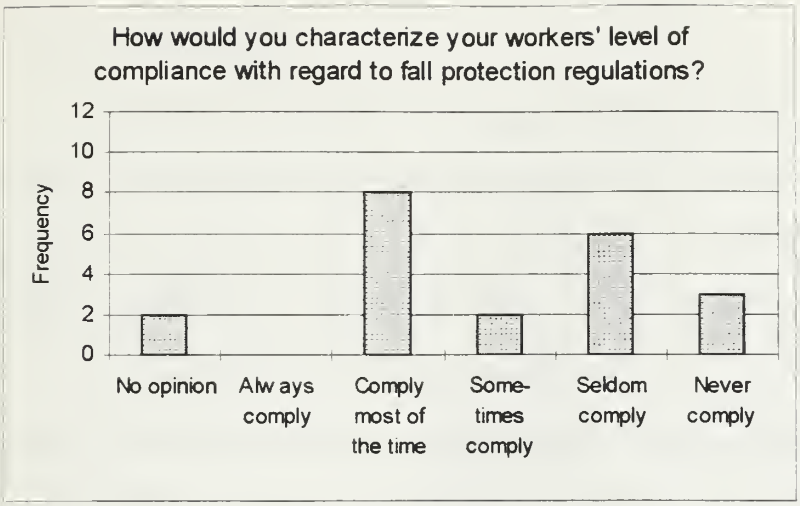

Figure 3.15: Level of worker compliance, as reported by construction managers

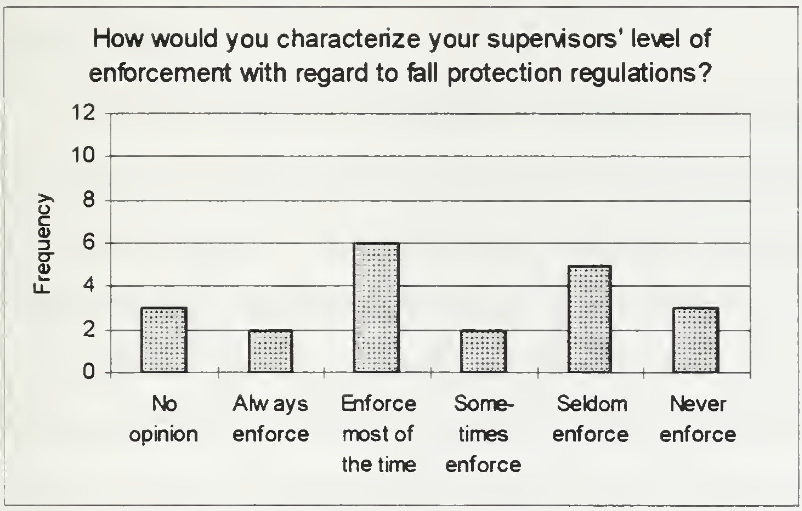

Figure 3.16: Level of supervisory enforcement, as reported by construction managers

3.2.6 Worker Behavior

The next question targeted the managers' beliefs as to the reasons behind their workers' behavior. Two construction managers were not asked this question, as they had no direct employees and were too far removed from the workers to adequately respond. Therefore, the sample population for this question was reduced to nineteen construction managers.

Since worker behavior was deemed to be the primary source of non-compliance, this question aimed at discovering why workers would or would not use fall protection. Figures 3.17 and 3.18 (following page) show the managers' responses. The managers believed that the primary reasons for worker compliance were due to supervisors and managers. Both supervisory enforcement and a requirement of employment were mentioned as being principal motivators for safe worker behavior, with six managers citing each factor. A personal concern for safety was believed to be a reason for compliance by three managers, while positive peer pressure was cited by two managers.

Reasons given for non-compliance, on the other hand, were primarily worker-centered. Almost 70% (n=13) believed their workers did not use fall protection because it slows them down. Over half (n=10) said that fall protection was not used because it was uncomfortable. The same amount stated that their workers believed that they would not fall, or the "it could never happen to me" attitude. Six believed that negative peer pressure and a macho attitude was a source of non-compliance. Only four managers looked at management as a source of non-compliance, pointing towards a lack of supervisory enforcement and/or a relaxed safety policy where fall protection is not a requirement of employment.

This once again emphasizes a confrontational atmosphere, where the construction managers are saying that the workers are a source of the problem and that the managers have the key to the solution. Many of the managers believe that they currently are doing as much as possible to enforce the regulations, but that the workers are not complying with them.

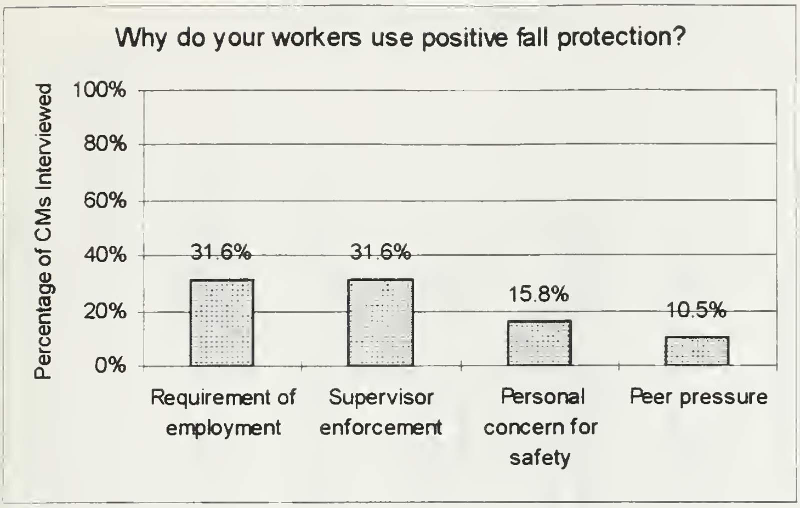

Figure 3.17: Reasons for worker compliance, as reported by construction managers

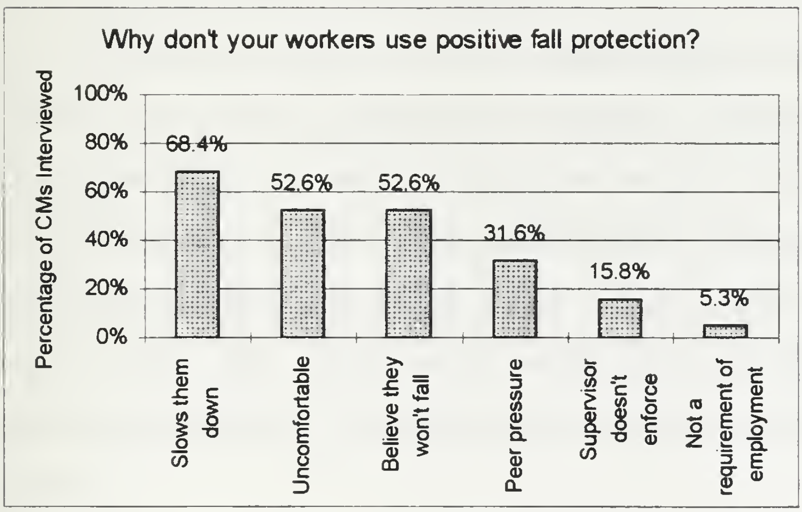

Figure 3.18: Reasons for worker non-compliance, as reported by construction managers

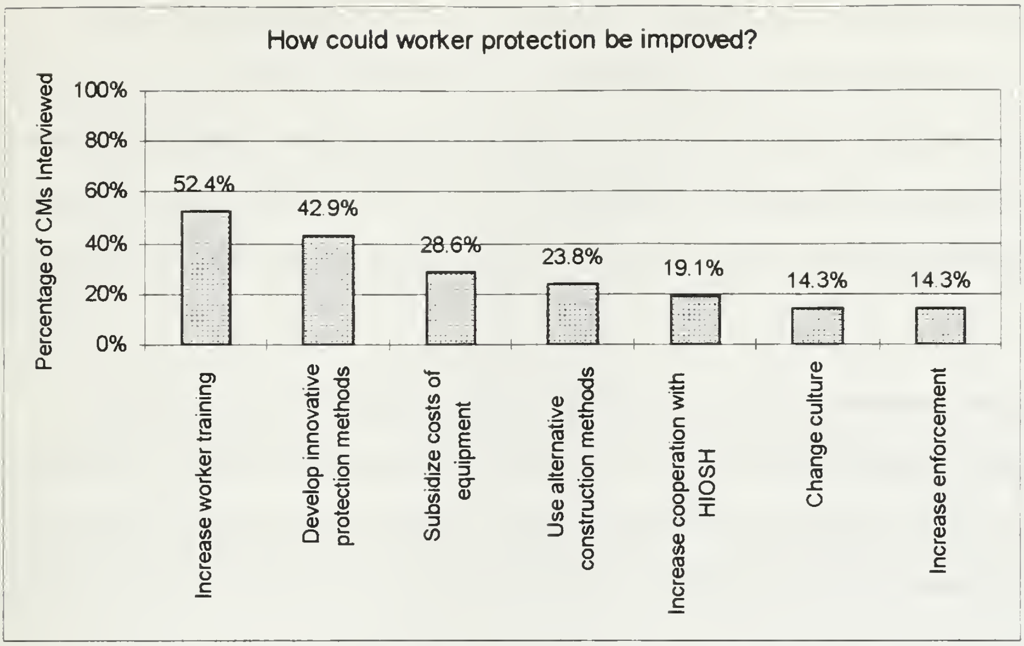

Figure 3.19: Actions for increasing worker protection, as reported by construction managers

3.2.7 Actions to Increase Worker Protection

The final core question of the interview involved solutions for increasing protection of the workers. Figure 3.19 shows the summary of responses. The primary solution proposed by the managers was to increase worker training, with over half (n=11) of the respondents believing that to be an important factor. Developing innovative methods of protecting the workers placed second, with nine respondents citing this solution. Because economics were the second-most frequently cited source of non-compliance, subsidizing the cost of fall protection systems was also frequently cited as a possible solution, with almost a third (n=6) recommending this approach.

Nearly one-fourth (n=5) of the managers stated that more innovative construction methods could be used, and several of them explained how these methods could protect workers. These methods include prefabrication and altering the sequence of construction to eliminate or greatly reduce the fall hazards to workers.

Other ideas to improve the level of compliance included increasing cooperation with HIOSH. The four construction managers who mentioned this also stated that currently, HIOSH is viewed as the enemy. "When they come on site," said one interviewee, " they just write you up for where you fail to comply. If you ask them, 'How can we do it and still be in compliance?' they give you the regulation and tell you that it's up to you to find a way" (Construction Manager #2, 1997).

Changing the culture was mentioned as a solution by three construction managers. The safety officer of Isemoto Construction and Fletcher-Pacific's Big Island operations believed that this change needed to start with children. "We could send out free coloring books on construction safety to all the contractors, who could give them to their employees to take home" (Norris, 1997).

Another solution mentioned was to increase enforcement. "Hit them in the pocketbook," said the same manager (*Ibid.*). Two other managers also felt that increased enforcement was necessary to increase compliance. However, increased enforcement was frowned upon by other construction managers. When asked directly whether increased enforcement would encourage or discourage compliance, three managers stated that it would discourage compliance.

In addition to those shown in Figure 3.19, there were several other solutions that were mentioned by individual construction managers, including:

(1) Make regulations more understandable and realistic. The current regulations are too impractical and too difficult to comprehend (Construction Manager #2, 1996).

(2) Increase risk managers' involvement. Insurance companies provide the *de facto* safety officer for many of Hawaii's homebuilders. Increased incentives and coercion from these companies and the state, in the form of workers' compensation rates, can go a long way towards changing the residential construction safety culture (Norris, 1997).

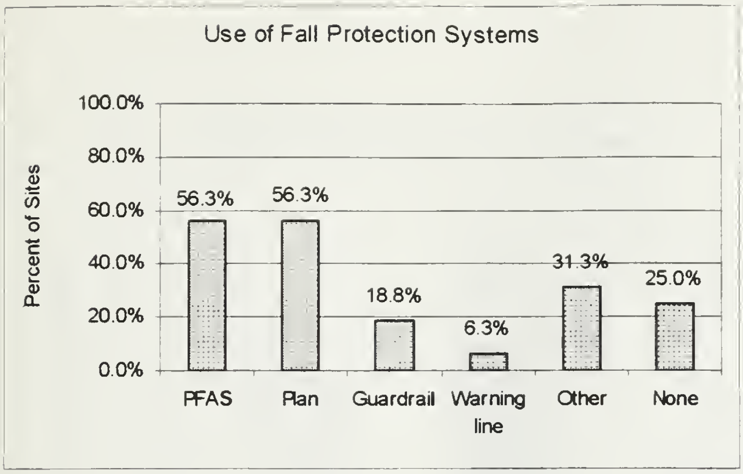

Figure 3.20: Fall protection systems in use in Hawaii's residential construction industry, as observed during job site inspections

(3) Make contractor licensing requirements more stringent. Require continuing education for all contractors in order to renew licenses. Ensure safety training is one of the continuing education requirements, along with other public health and safety issues (Lyons, 1997).

3.3 Job Site Inspections

The results of the job site inspections were analyzed quantitatively. First, the sixteen job site inspections shown in Table 3.1 (page 41) were recorded on inspection sheets (see Figure 3.2, page 42). Data was then transposed into the database given in Appendix D.

3.3.1 Use of Fall Protection Systems

Fall protection systems in use on the sites inspected are shown in Figure 3.20. Over half (n=9) of the job sites inspected employed the PFAS and/or the fall protection plan. Almost 20% (n=3) utilized a guardrail system, while just one site employed a warning line system. Almost a third of the sites (n=5) employed other innovative methods of fall protection, including innovative

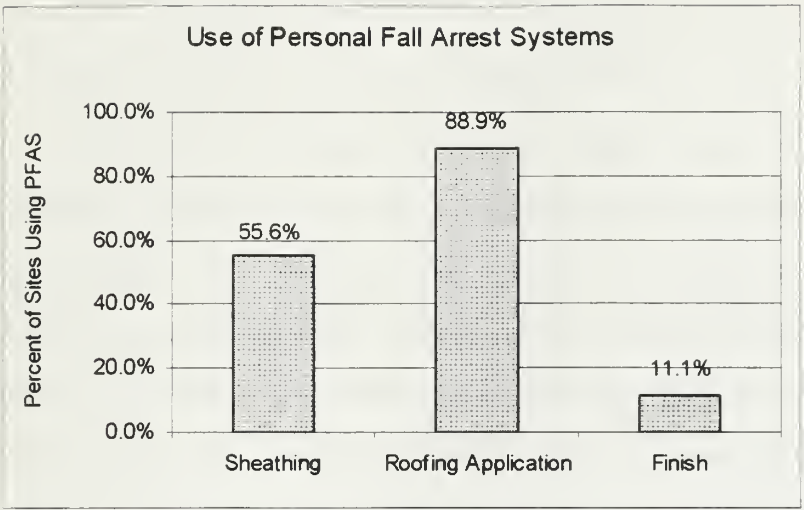

Figure 3.21: Use of personal fall arrest systems, as observed during job site inspections

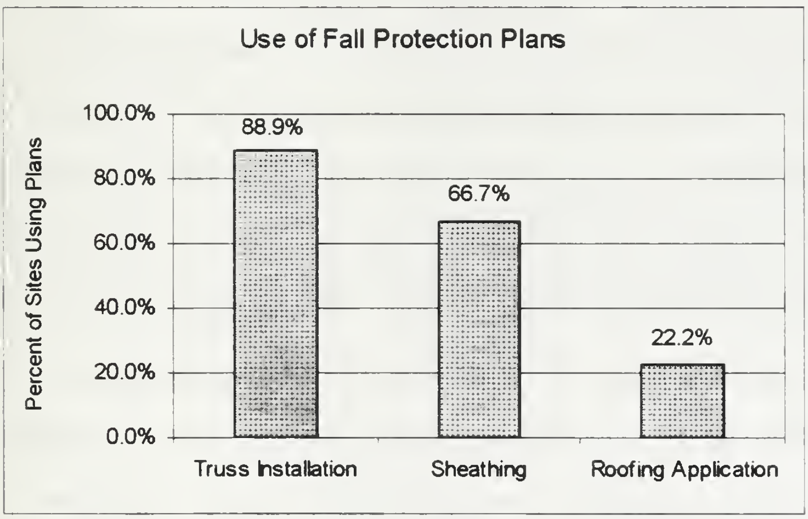

Figure 3.22: Use of fall protection plan, as observed during job site inspections

design and construction methods, such as prefabrication of roof systems on the ground. Fully one-fourth (n=4) of the sites inspected employed no fall protection systems at all. These four sites were all in the single homeowner sector. Not surprisingly, these findings are similar to those found during the interviews. In fact, the correlation is high, at r = 0.90.

Additionally, the findings reinforce the construction managers' theory that there is an appropriate use for each of the various fall protection systems, as shown in Figures 3.21 and 3.22 (preceding page). The fall protection plan was most commonly used during truss installation. The only other observed practice in use during truss installation was to use scaffolds on the interior of the second story and work from the scaffolds. PFAS was most frequently used for roofing application. The use of both PFAS and the fall protection plan were common in roof sheathing. Correlation between interviews and inspections for PFAS use is r = 0.97; for plan use, it is r = 0.87. Therefore, the inspection findings on the use of fall protection systems are consistent with the findings of the interviews.

3.3.2 Worker Compliance and Supervisor Enforcement Levels

Worker compliance and supervisory enforcement levels were assessed during the job site inspections. The findings are presented in Figures 3.23 and 3.24 (following page). As shown in Figure 3.23, worker compliance is actually quite poor. Of the sixteen sites, only three were assessed as having worker compliance above a level of "sometimes," while ten were below this level. On none of the sites did the workers always comply with regulations.

Supervisory enforcement, while better than worker compliance, was also poor, as shown in Figure 3.24. Only one site received an assessment of "always enforced." On another five sites, supervisors mostly enforced regulations. Ten sites were below a level of "sometimes" with regards to supervisory enforcement of fall protection regulations.

If the scores are assessed on a scale of 1-5, with 1 being "always comply" and 5 being "never comply," then means can be established. The worker compliance mean was 3.69, and the

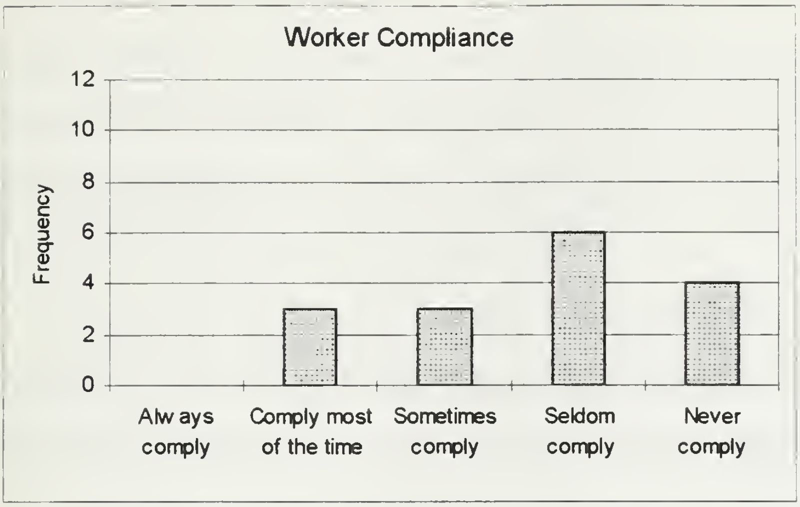

Figure 3.23: Level of worker compliance, as observed during job site inspections

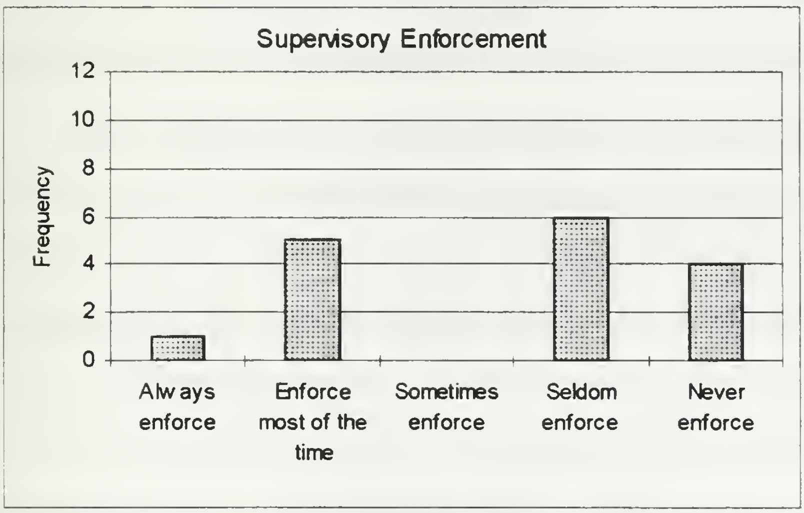

Figure 3.24: Level of supervisory enforcement, as observed during job site inspections

supervisory enforcement mean was 3.44 for all sites. Both of these are in the range between sometimes and seldom comply/enforce. If the perceptions of the construction managers are also assessed numerically, then means can be established for their perceptions as well, and a comparison of the perceptions and reality can be made. The means of the construction managers' perceptions are 3.21 for worker compliance, and 2.89 for supervisory enforcement, a 13% and 16% difference from the assessed scores.

The correlation between the managers' perceptions and the job site inspections was assessed for both the worker compliance level and the supervisory enforcement level. The correlation for worker compliance was $r = 0.62$; for supervisory enforcement, it was $r = 0.87$.

The percent differences indicate that the managers have a false perception of their compliance and enforcement levels. However, the positive correlation results show that the managers' perceptions, while not coinciding with reality, are at least similarly, albeit more generously, distributed. These results indicate that there may be a lack of knowledge regarding the proper implementation of fall protection regulations in Hawaii's residential construction industry, which could be brought about by the complexity of the regulations.

The compliance and enforcement scores of the sites inspected can also be used to compile average scores for various sectors of the residential construction industry. Table 3.2 (following page) gives the average scores for three sectors--the public sector (n=5), the private developer sector (n=7), and the private single homeowner sector (n=4). The results show that the public sector sites had the best levels of worker compliance and supervisory enforcement, followed by the private developer sector. The private single homeowner sector was disappointingly unsafe. As mentioned previously, none of the four job sites had taken any measures to protect their workers from falls.

Table 3.2: Average compliance and enforcement levels by sector, as observed during job site inspections

Industry Sector	Worker Compliance Level	Supervisory Enforcement Level
Public sector	2.80	2.80
Private developer	3.57	3.00
Single homeowner	5.00	5.00
Overall industry	3.69	3.44

3.4 Summary of Findings

The findings of the construction managers' interviews and the job site inspections can be summarized as follows:

(1) The current state of compliance is split, with 57% feeling compelled to comply and 43% feeling compelled not to comply. Complying with the regulations poses problems for most construction managers on a frequent basis. Worker behavior was cited most frequently (by 80% of the managers) as a significant problem. Other problems encountered include economic-related problems, productivity-related problems, design-related problems, subcontractor-related problems, problems related to construction methods, and a lack of training and/or knowledge. Thus, the character of non-compliance is varied, and involves all parties in the residential construction industry.

(2) Construction managers utilize a wide variety of fall protection systems, but are most familiar with and most frequently employ PFAS and fall protection plans. Construction managers feel that each system offers unique advantages, and indicate that there is an appropriate use for each system. PFAS is most commonly used for roofing application; the plan is most commonly used for truss installation.

(3) Construction managers are split on their opinions regarding the need for positive protection, although a slight majority (52%) feels that it is required on roofs with slopes exceeding 4:12. An additional 19% feel that positive protection is needed above 8:12, while 29% feel that positive protection is never required.

(4) Construction managers believe that their own sites are more in compliance than the actual inspections show. This indicates a lack of knowledge regarding the true requirements of Subpart M.

(5) The levels of compliance found during the job site inspections show that compliance improves with external supervision. None of the four single homeowner sites inspected was in compliance. Compliance improved on the private developments. The highest degree of compliance was found on public sector projects, where there was a high degree of owner involvement and oversight.

(6) Construction managers feel that their workers most often comply with regulations because of management's actions to ensure compliance (i.e., supervisory enforcement, making compliance a condition of employment). On the other hand, they believe that worker non-compliance is due primarily to the worker's perceptions that fall protection gets in the way, is uncomfortable, and is unnecessary. This indicates a confrontational stance where management feels that workers are the source of the problem and management holds the only key to its solution.

(7) Construction managers felt that the most important action that could be taken to improve worker protection is to increase worker training. Developing innovative protection methods was also felt to be an important action to improve protection. Many other alternative actions were mentioned by the construction managers, indicating once again that the problem with the current state is a multi-faceted one involving all parties in residential construction.

3.5 Contractors' Requirements

The information obtained from the interviews and job site inspections form the basis for presenting the issues and interests of the contractors. In developing appropriate alternative fall protection systems, the following issues and interests are paramount to contractors:

(1) The costs of fall protection systems should not exceed the benefits. Otherwise, the contractor will feel compelled not to utilize the system.

(2) The system should be flexible, and applicable to the various conditions found on site. Some systems are preferred over others for different phases of roof construction.

(3) The system should be passive. Systems that require workers to take an active part in protecting themselves, such as PFAS, are considered by the workers to be uncomfortable and to get in the way. Because of this, they are often not used, and are therefore difficult for supervisors to enforce.

(4) The system should be able to be implemented for various designs and using standard construction methods. For example, it should not require use of equipment that is not normally found on the job site.

(5) The system should not be difficult to understand nor to implement. The current regulations allow for too many interpretations, and are incomprehensible to most contractors. Only those contractors with a full-time safety representative seem to understand all requirements of the regulations.

Each of the above requirements must be satisfied for an alternative proposal to be considered to be in the interests of the contractor. Since the contractor is ultimately responsible for protecting his or her employees from falls, his or her interests must be taken into account when developing alternative proposals. These alternative proposals will be presented in Chapter 6.

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Construction Manager #2--Anonymous (1997). Second interview and field site visit. Central Oahu, HI. February 18.

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Chapter 4: Labor's Views

4.1 Methodology of Investigation

The second party to be analyzed was labor--the carpenters and roofers who build the homes. This investigation involved two sub-steps:

(1) Interviews of union officials

(2) Survey of workers

The methods undertaken for each of these steps will be reviewed below.

4.1.1 Interviews of Union Officials

Interviews were obtained with the Training Coordinators of Roofers Local 221 and Carpenters Local 745. The interviews were aimed at gathering the unions' views on the following issues:

(1) The current state of compliance, and factors leading to non-compliance

(2) Use of fall protection systems, especially the workers' preferences with regard to existing methods

(3) Actions to increase protection of the workers

The results of the interviews are given in section 4.2, below.

4.1.2 Surveys

Based on the ideas proposed by the contractors and the union representatives, a survey was developed to obtain the workers' views on fall protection. The survey form is shown in Appendix E. The survey included four sections. The first section, "Information About Yourself," included demographics questions regarding experience, trade, union membership, marital status,

children, and exposure to fall hazards. The next section, "Accident History," asks the worker if he or she has been involved in or observed any fall accidents in the past three years. The third section, "Your Employer's Safety Program," was aimed at finding the worker's exposure to various fall protection systems. The fourth and final section, "Your Opinions on Fall Protection," asked the worker how he or she felt about current fall protection regulations and methods. The questions in this portion of the survey can be grouped into the following major categories:

(1) An appropriate use matrix (question #5), which asked the workers what they considered to be the most appropriate method of fall protection for each phase of roof construction,

(2) Use of positive protection (questions #1 and #2), including both frequency of use and necessity for use,

(3) The relative dangers of various roofing surfaces (questions #3 and #4),

(4) Problems encountered by workers in complying with fall protection regulations (questions #6 and #7), including both frequency of problems and sources of problems,

(5) Reasons for use and non-use of fall protection systems (questions #8 and #9),

(6) Levels of supervisory enforcement (question #10) and self compliance (question #11), and

(7) Actions to increase protection (question #12).

The survey was distributed to the workers through the two unions' Training Coordinators, who also collected them and returned them to the researcher. Twenty-three surveys were returned to the researcher, including thirteen carpenters and ten roofers. All but one of the surveys were completed by apprentices; however, these apprentices had up to ten years of experience in the construction industry. The surveys were analyzed as described in section 4.3.

4.2 Interviews with Union Officials

The information obtained through interviews with union officials was analyzed qualitatively. Notes from the interviews were first transposed into reports, which were organized along the three core issues given in section 4.1.1, above. Supplemental information was also recorded on the reports. Since only two interviews were involved, a database was not required for this analysis. Instead, a narrative analysis is given below.

4.2.1 State of Compliance

Both unions felt that the current state of compliance was poor. Unlike the contractors, however, the unions felt that the issue was related to poor management, not to worker behavior. They felt that the principal contributor to fall accidents, and the lack of fall protection, was the contractors' push for production at the expense of safety. This is manifest in several ways:

(1) The contractors may not assign enough workers to a job. For instance, when installing fascia, contractors may assign the task to one carpenter, who must install the 8 ft long 2" x 8" plank along the eaves (Mactagone, 1997).

(2) The contractor may not provide enough time for the task to be done safely. When scheduling the fascia installation, the contractor typically does not include time for setting up scaffolds around the house (Mactagone, 1997).

(3) The contractor may pay at a piecemeal rate. Although this is against the collective bargaining agreements with union shops, non-union contractors typically do pay wages according to production, not time. This encourages workers to skimp on safety in order to speed up their production (Chong and Subiono, 1997).

(4) The contractor may not provide the right equipment. Although this also is against collective bargaining agreements, even some union framing

contractors expect their employees to provide their own tools, to include safety equipment (Mactagone, 1997).

(5) The contractor may not provide sufficient training. Each apprentice training program includes rudimentary safety training, but no further. Contractors must provide training on the fall protection systems they employ on site (Chong and Subiono, 1997, and Mactagone, 1997).

(6) The contractor may not be knowledgeable. The contractor may not understand the regulations, and may just consider the hazards to be a part of the employees' job requirements (Chong and Subiono, 1997).

The unions also placed some of the blame on the residential construction industry as a whole, especially in the single homeowner sector of the industry. Although they acknowledged that there were some safety-conscious operations in this sector, both unions portrayed this sector as largely unregulated, involving mostly unlicensed contractors and unqualified workers.

However, the unions also acknowledged that worker behavior may be a source of non-compliance. The Hawaiian construction culture includes a "macho attitude," and there are some workers who take unnecessary risks. But, the unions went on to say, if the workers felt their lives were in danger, and they were provided with the right equipment and training, they would use the equipment.

4.2.2 Use of Fall Protection Systems

The unions did agree with the contractors that the workers do not particularly like to use systems, like the PFAS, which require their active participation. These types of systems get in the way, slow them down, and trip them up. They much prefer to use passive systems, such as guardrails and scaffolds.

The unions also felt that some of the alternative forms of fall protection, such as the fall protection plan, did not take into account the safety of the workers. They suggested instead that contractors try to eliminate the hazards. For example, a framing contractor could erect scaffolds or work platforms on which the workers could walk instead of on the top plates of the walls.

4.2.3 Actions to Increase Worker Protection

The unions offered several ideas to increase protection, including:

(1) Continue to educate union and non-union workers in their rights to a safe workplace, through job site visits by union officials (Chong and Subiono, 1997, and Mactagone, 1997).

(2) Increase cooperative efforts between contractors and HIOSH. Increase consultation services (Mactagone, 1997).

(3) Increase regulatory oversight of single homeowner sector, by requiring permits for reroofing and other repairs that normally do not require permits (Chong and Subiono, 1997).

(4) Educate homeowners in their responsibilities to ensure a safe working environment for contractors performing construction and repair of their homes (Chong and Subiono, 1997).

4.3 Worker Surveys

Results from the worker surveys, described in section 4.1.2, were analyzed quantitatively. A database was developed to store, sort, and analyze the information obtained. The data, given in Appendix E, were analyzed using charts and statistics, as described below.

4.3.1 *Accident Frequency and Severity*

The accident history portion of the survey was useful in determining the impact of fall accidents in Hawaii's residential construction industry. Workers were asked for the number of falls they had observed during the past three years. Of the twenty-two respondents to this question, almost one-fourth (n=5) said that they had witnessed one or more fall accidents. These five workers had witnessed seven fall accidents, including one resulting in permanent disability and two resulting in fractures. This underscores the seriousness of fall accidents in the residential construction industry.

4.3.2 *Use of Fall Protection Systems*

The next portion of the survey asked the worker about his or her employer's safety program. Most of this portion of the survey was not analyzed; following return of the surveys, it became apparent that many of the workers did not know enough about their employer's safety programs to answer these questions. However, this portion of the survey was useful in examining the workers' exposure to different fall protection systems.

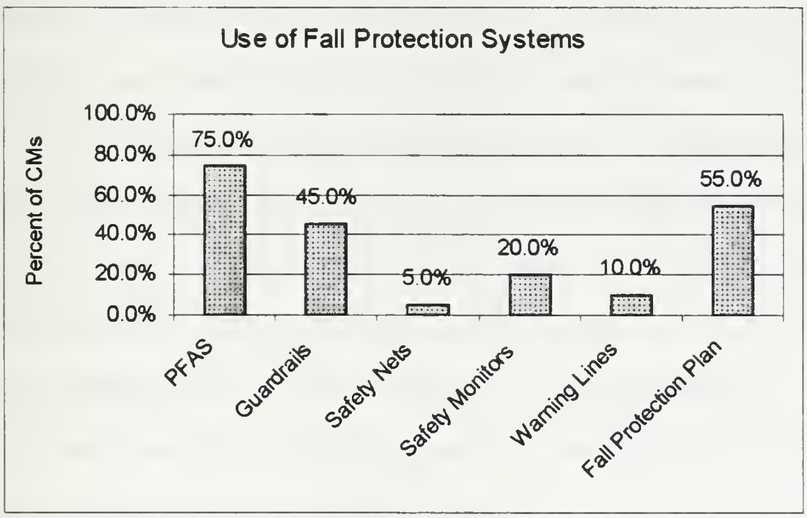

Figure 4.1: Fall protection systems in use in Hawaii's residential construction industry, as reported by workers

Figures 4.1 through 4.8 (pages 75-81) all deal with the current use of fall protection systems in Hawaii's homebuilding industry. Workers were first asked which systems their employers had used on residential roof construction. Three workers did not answer this question, resulting in a sample population for this question of n=20. Figure 4.1 (preceding page) shows that employers most frequently use PFAS, with 75% (n=15) of workers stating that their employers used this system. The second most frequently used system is the fall protection plan. Over half (n=11) of the workers' employers used a fall protection plan. The remaining fall protection systems, including guardrails, safety nets, safety monitors, and warning lines, were each used by less than half of workers' employers. Only one worker's employer used safety nets. The responses to this question correspond well to the construction managers' uses of fall protection methods; in fact, the correlation is r = 0.96. Like the managers, the workers had been exposed to many systems, but were most familiar with the PFAS and the fall protection plan.

Figures 4.2 and 4.3 (following page) show how workers' employers utilized the two most common forms of fall protection systems--PFAS and fall protection plans, respectively. Unlike the managers, workers stated that PFAS are most commonly used during roof sheathing. However, they also had observed PFAS in use during roof application and, surprisingly, during truss installation, as shown in Figure 4.2. Correlation analysis shows that there is no correlation (r = 0.09) between the workers' observations and those of the construction managers. Fall protection plans were used equally in both truss installation and roof sheathing, and, to a lesser degree, in roofing application, as shown in Figure 4.3. For plan use, the correlation between the construction managers' and workers' opinions is higher, at r = 0.65. It appears, then, that workers have a different perception of PFAS than the construction managers. Perhaps the workers were not as well-versed in the different systems they employed. This could indicate a lack of knowledge and training on the workers' part.

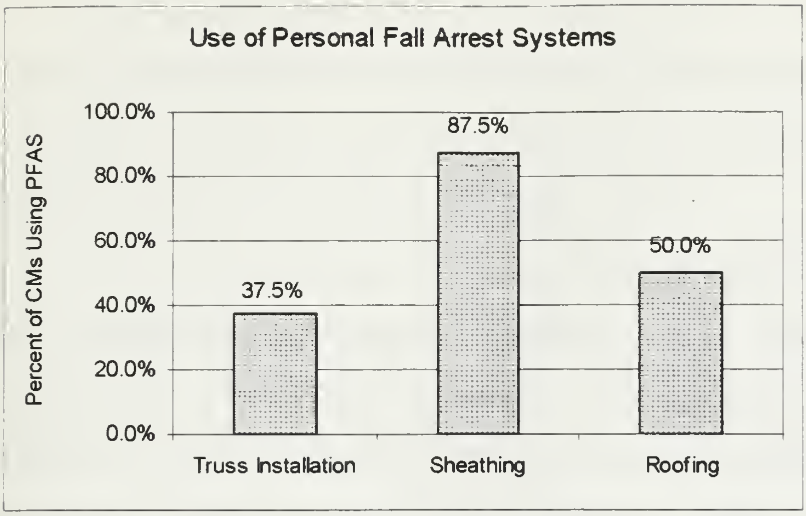

Figure 4.2: Use of personal fall arrest systems, as reported by workers

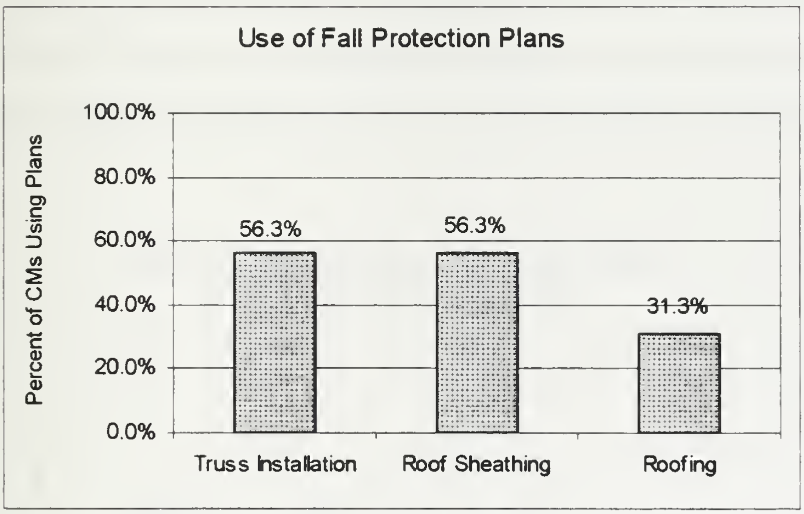

Figure 4.3: Use of fall protection plans, as reported by workers

Figures 4.4 through 4.8 (pages 78-81) show the workers' responses to targeted questions regarding which form of fall protection was most appropriate for each phase of roof construction. The phases included truss installation, roof sheathing, and roofing application, at slopes of less than 4:12, 4:12 to 8:12, and greater than 8:12.

The results are surprising. Figure 4.4 indicates that workers believe that PFAS is the most appropriate form of fall protection during truss installation. In contrast, the construction managers felt that the fall protection plan was the most appropriate system to use during truss installation. Correlation analysis indicates no correlation ($r = 0.15$) between the two populations with regard to protecting workers during truss installation. However, a complete PFAS requires an anchor point that is capable of withstanding 5000 pounds of force, as discussed in Chapter 2. It is unlikely that the frame of a house prior to truss installation can withstand this amount of force. The anchor point would therefore need to be installed on another structure, such as a pair of telephone poles with a lifeline to connect them, on each side of the house. This method would not be considered to be economical by contractors, and it is therefore unlikely that PFAS would be an appropriate method of protection for most residential truss installations.

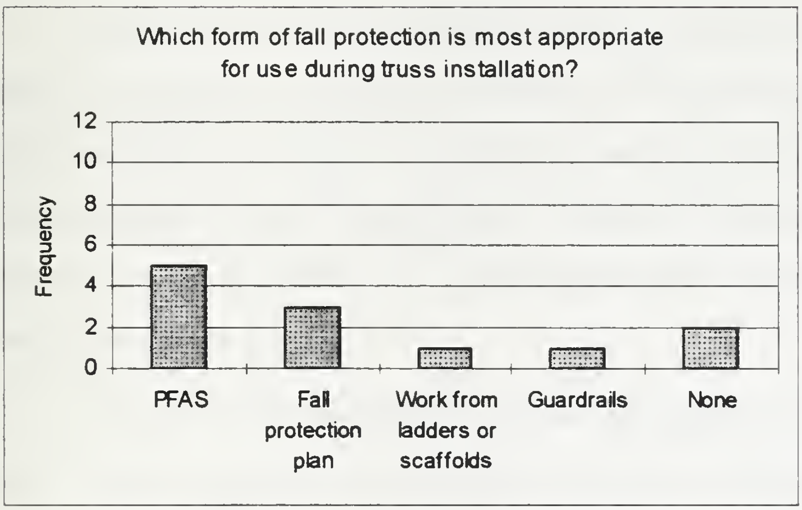

Figure 4.4: Appropriate fall protection for truss installation, as reported by workers

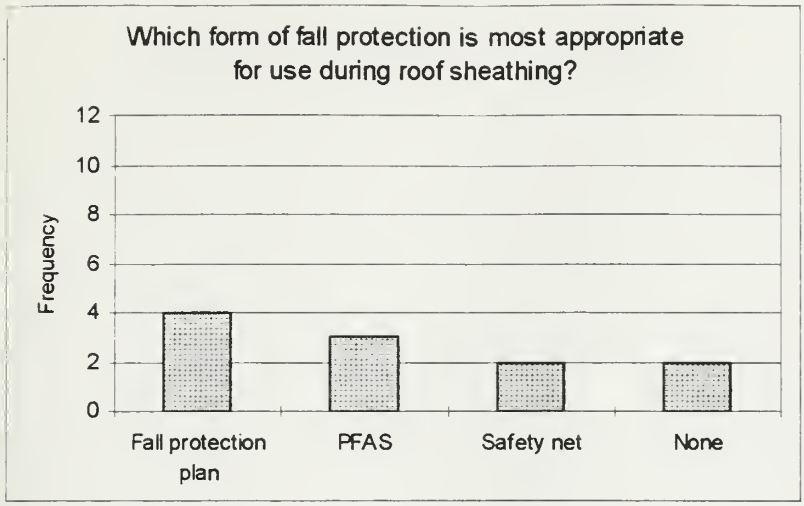

Figure 4.5: Appropriate fall protection for roof sheathing, as reported by workers

Figure 4.5 shows that workers, like construction managers, are split between preferring fall protection plans and PFAS during roof sheathing. Two workers indicated that safety nets would be their preferred method of protection, while another two workers indicated that no existing system would be appropriate for protection during roof sheathing. The correlation for this question between the managers and the workers is quite high, at r = 0.66.

Figures 4.6 through 4.8 (pages 80-81) provide the workers' preferences for fall protection during roof application. For low-sloped roofs (roofs with slopes below 4:12), the workers felt that fall protection plans and guardrails were the most appropriate forms of protection, followed by PFAS, as shown in Figure 4.6 (following page). Correlation between workers' opinions and managers' opinions is low, at r = 0.27, primarily due to the range of responses from both the workers and the managers.

Correlation between the managers and workers improved as the slope increased. In Figure 4.7 (following page), for roofs between 4:12 and 8:12, the workers' options expanded, with the safety monitor option being added as a most preferred method. However, the PFAS became the most preferred method, followed by the fall protection plan, then guardrails.

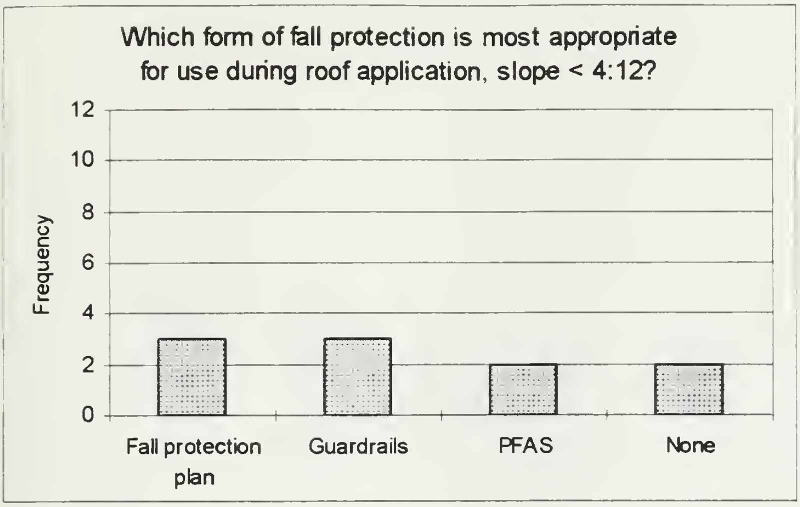

Figure 4.6: Appropriate fall protection for roofing application, slope < 4:12, as reported by workers

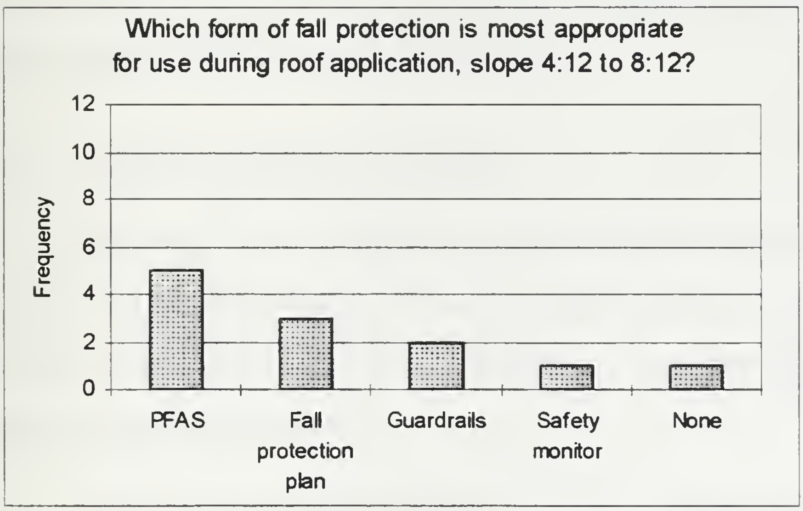

Figure 4.7: Appropriate fall protection for roofing application, slope 4:12 to 8:12, as reported by workers

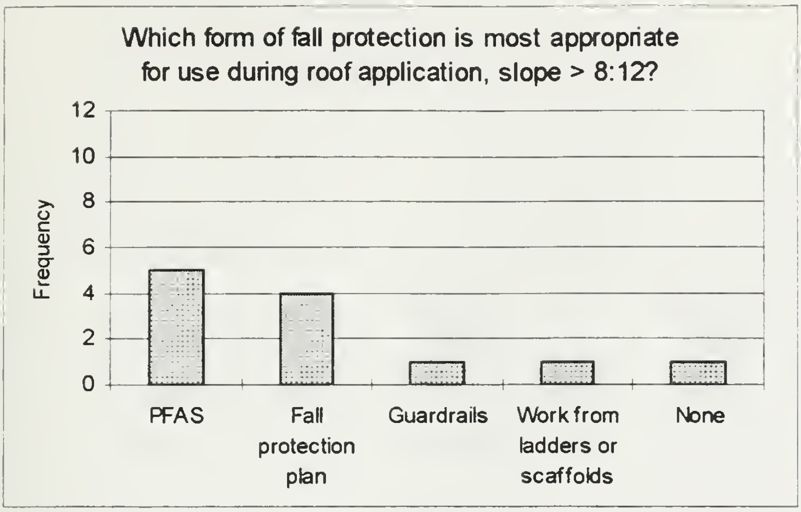

Figure 4.8: Appropriate fall protection for roofing application, slope > 8:12, as reported by workers

Figure 4.8 shows the responses for roofs with slopes above 8:12. At this point, the PFAS remains the primary method of choice among workers. Surprisingly, however, the fall protection plan remains cited by almost as many respondents. Still, correlation with managers' opinions is quite high for all slopes above 4:12, at r = 0.72.

4.3.3 Necessity for Positive Fall Protection

The next grouping of questions dealt with the workers' views as to the necessity for positive fall protection as opposed to alternative fall protection. This included both the frequency of use of positive fall protection systems by workers, and workers' beliefs regarding the need for positive fall protection systems.

The frequency of use was obtained from the answers to question #1. The possible responses ranged from "Always" to "Never," and are presented in Figure 4.9 (following page). The responses were assessed a score from 1 to 5, with 1="Always" and 5="Never." The mean response for this question was a 2.8, between "Frequently" and "Sometimes." This indicates that workers often use some positive form of fall protection when exposed to fall hazards.

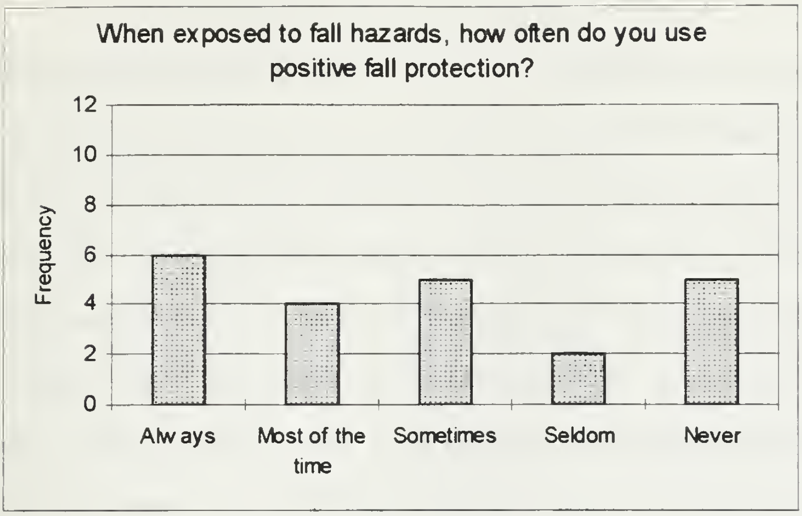

Figure 4.9: Personal use of positive fall protection, as reported by workers

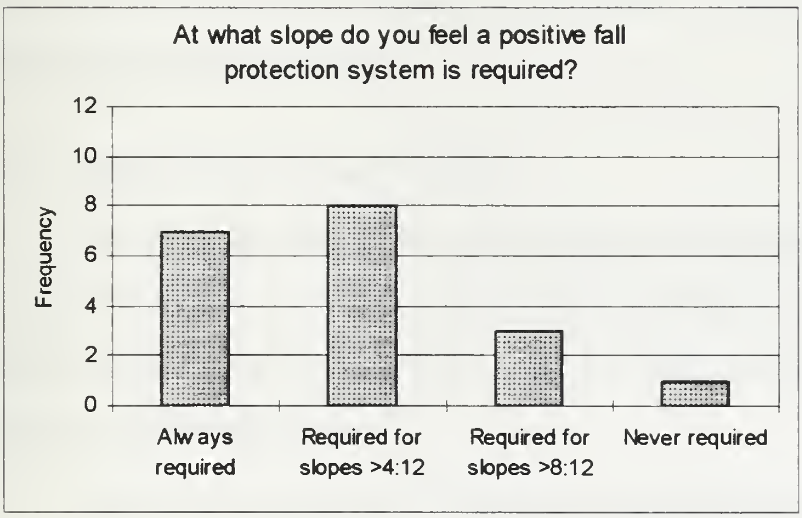

Figure 4.10: Necessity for positive fall protection, as reported by workers

The workers' beliefs regarding when positive fall protection was necessary were analyzed through their responses to question #2. Figure 4.10 (preceding page) shows the frequency of responses for this question. Seven respondents believed that positive fall protection was always required, and only one believed that it was never required. Eight felt that it was necessary at slopes above 4:12, and another three felt it was unnecessary until the slope exceeds 8:12. These responses do not support the findings for appropriate use of fall protection systems identified above. These responses indicate that as the slope increases, the systems should become more positive; however, the responses to the appropriate use questions did not seem to support this trend. This contradiction seems to show that the current fall protection regulations are not well understood by the individual workers.

These responses were also compared to those of the construction managers using correlation analysis. The result ($r = -0.04$) indicate that the managers and workers have different perceptions regarding the proper use of positive protection. Workers appear to desire positive protection at lower slopes than managers feel is necessary. This could be a source of contention between workers and management.

4.3.4 Relative Danger of Roofing Surfaces

The next set of questions (#3 and #4) asked the workers' opinions as to the relative dangers of the various working surfaces found during residential roof construction. 68% of respondents felt that the surface should be taken into consideration when choosing an appropriate fall protection system.

Question #4 asked the respondents to rank common roofing surfaces according to their relative dangers. Each worker ranked the seven surfaces from 1-7; the rank was assessed a point value from 0-6, with six for the most dangerous surface and zero for the least dangerous surface. The point values for the various surfaces are shown in Figure 4.11 (following page).

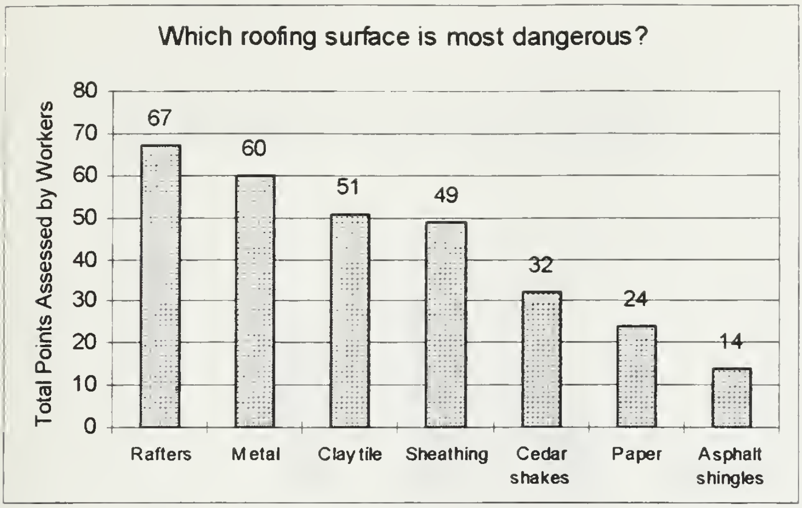

Figure 4.11: Relative danger of various working surfaces, as rated by workers

As shown, the most dangerous surface, according to the workers, is the truss system without sheathing, or bare rafters. Metal and clay tile roof systems followed, and bare sheathing was considered the next most dangerous. Cedar shakes, paper, and asphalt shingles were considered to be the least dangerous surfaces.

4.3.5 Problems Encountered with Compliance

The fourth group of questions asked the workers how frequently they encountered problems that made it difficult for them to comply with the regulations (question #6), and also how they would characterize these problems (question #7). Figures 4.12 and 4.13 (following page) show the workers' responses.

The workers seemed to encounter problems less frequently than did the construction managers. Over half of the construction managers had felt that they encountered problems frequently or all of the time, while just over a third (n=6) of workers felt they frequently encountered problems, and none felt that they always encountered problems. Most (n=7) felt they sometimes encountered problems. Three seldom encountered problems, while only one

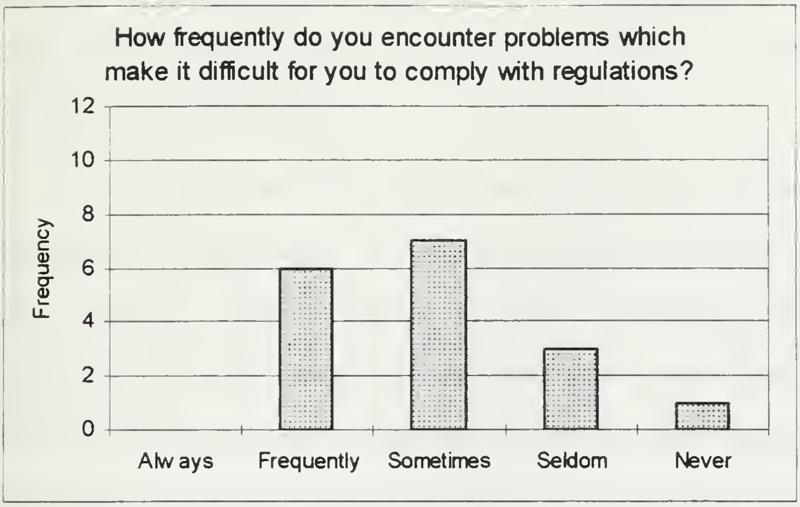

Figure 4.12: Frequency of non-compliance, as reported by workers

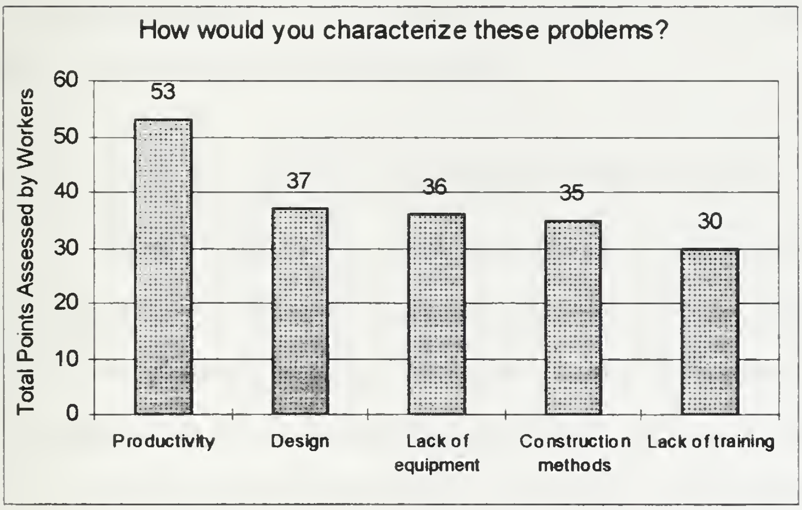

Figure 4.13: Sources of non-compliance, as rated by workers

stated that he or she never had any problems complying with the regulations. Correlation analysis confirms that, while there is a positive correlation between the managers and workers in this regard, it is not very high (r = 0.52). Thus, the workers do in fact have less problems with compliance than management.

The workers were then asked to rank several potential causes of non-compliance according to their frequency. The ranks (1-6) were then converted to point values from five to zero, accordingly. Figure 4.13 shows the results of the voting process. The most frequently occurring source of non-compliance, according to the workers, was productivity-related. This category received 40% more points than the next most frequently occurring source, which was design-related. A lack of equipment and greater hazard due to construction methods were cited as the third and fourth most frequently occurring sources, and a lack of training was significantly below these as the fifth most common source of problems.

These responses were quite different from those of the construction managers. Whereas the construction managers primarily indicated that most compliance problems were worker-related, the workers feel that most compliance problems are management-related, especially the push for productivity at the expense of safety.

4.3.6 Worker Compliance and Supervisor Enforcement Levels

Questions #10 and #11 asked the workers how they would characterize their own level of compliance with fall protection regulations, and their supervisors' level of enforcement of the regulations. Figures 4.14 and 4.15 (following page) show the workers' frequency of responses. The workers took a more positive view of both their own level of compliance and their supervisors' level of enforcement than did the construction managers.

As shown in Figure 4.14, over three-fourths (n=13) of the workers felt that they always or mostly complied with the regulations. Another two stated that they sometimes comply, while two more said they seldom complied with regulations. None of the workers stated that they never

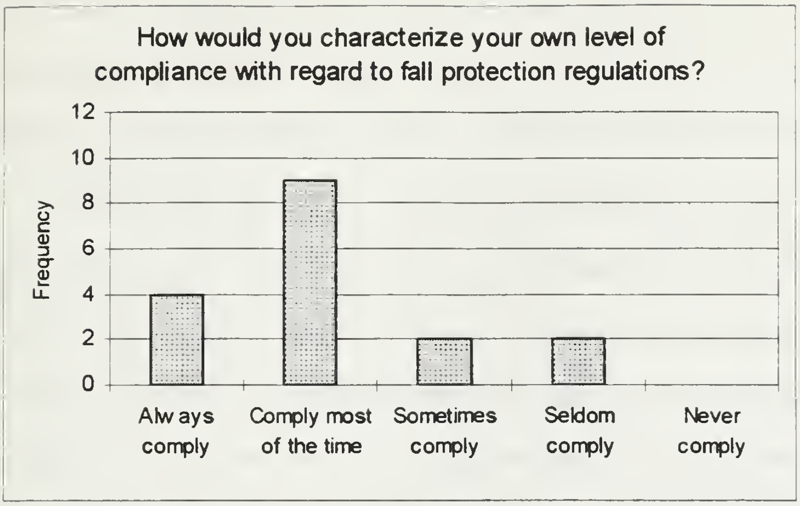

Figure 4.14: Level of worker compliance, as reported by workers

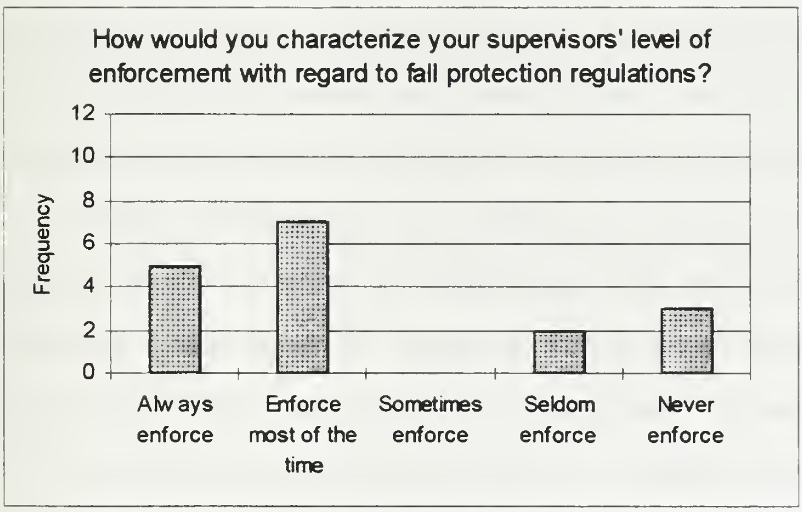

Figure 4.15: Level of supervisory enforcement, as reported by workers

complied with regulations. The mean of responses regarding the workers' own compliance was a 2.12, just barely below the "Comply most of the time" category. In contrast, the managers had rated their workers' compliance as a 3.21, between "Sometimes" and "Seldom comply."

Regarding supervisory enforcement, the workers were again very positive, as shown in Figure 4.15. 70% (n=12) of the respondents felt that their supervisors enforced the regulations most or all of the time, while the remaining 30% (n=5) felt that their supervisors seldom or never enforced regulations. The mean of responses regarding the workers' perceptions of their supervisors' enforcement was a 2.47, between "Most of the time" and "Sometimes." The managers had also rated their supervisors in this general area, at a mean of 2.89. This indicates that workers, unlike management, have not adopted a confrontational stance on this issue.

The differences between the managers' perceptions and the workers' perceptions are quite large. In the area of worker compliance, there is a 34% difference between perceptions. However, the gap between the workers' perceptions and the reality as found in job site inspections is even larger. In worker compliance, where the job site inspections gave a mean compliance score of 3.69, the difference between workers' perceptions and reality is over 40%. In supervisory enforcement, the difference is only 28%, as the job site inspection mean was 3.44.

Correlation analysis was also conducted on the frequency of responses between the managers, workers, and inspection results as follows. For worker compliance, there is a positive correlation ($r = 0.53$) between the managers and the workers, showing that while the distribution is somewhat similar, the responses are not well correlated. Likewise, the workers' opinions were compared to the results of the job site inspections. Correlation for these two samples is negative, at $r = -0.32$, indicating that the responses of the workers are quite different from the actual state of compliance as found by the job site inspections. Therefore, the workers have a more generous view of their own compliance than both management believes and reality portrays. This indicates that the workers may not be knowledgeable about the regulations; if they believe they are complying, yet inspections show they aren't, maybe the issue is one of training.

For supervisory enforcement, there is a moderate correlation between the managers' and workers' responses, at r = 0.50, and a slight correlation between workers' responses and job site inspection results, at r = 0.34. Therefore, although the distribution of workers' responses is somewhat similar to those of the managers and to the inspection results, the workers were again more generous. These findings also indicate that the workers are unfamiliar with the actual requirements of Subpart M.

Analysis of variance (ANOVA) was conducted on the three populations' mean responses for worker compliance and supervisory enforcement. For α = .05, one-way ANOVA gives F = 17.0, which is greater than the F-criteria of 9.55. Therefore, the difference between the worker responses, managers' responses, and the inspection results is significant, and not due to chance.

4.3.7 *Worker Behavior*

Since the managers believed that worker behavior was a major source of non-compliance, two questions were included in the worker survey to obtain their reasons for using (question #8) and not using (question #9) fall protection equipment. Both questions asked the respondents to rank common reasons from most frequent to least frequent, and points were assessed from zero to five, according to their rank. Figures 4.16 and 4.17 (following page) show the results of the votes.

The managers had believed that the primary reasons for worker compliance were management-centered. The workers, however, stated that they were principally motivated by a concern for their personal safety, indicating that the primary reason they comply with regulations is worker-centered, not management-centered. Correlation analysis for the two samples indicates that the correlation is only moderate (r = 0.59), supporting the findings that the two parties have different views regarding why workers comply.

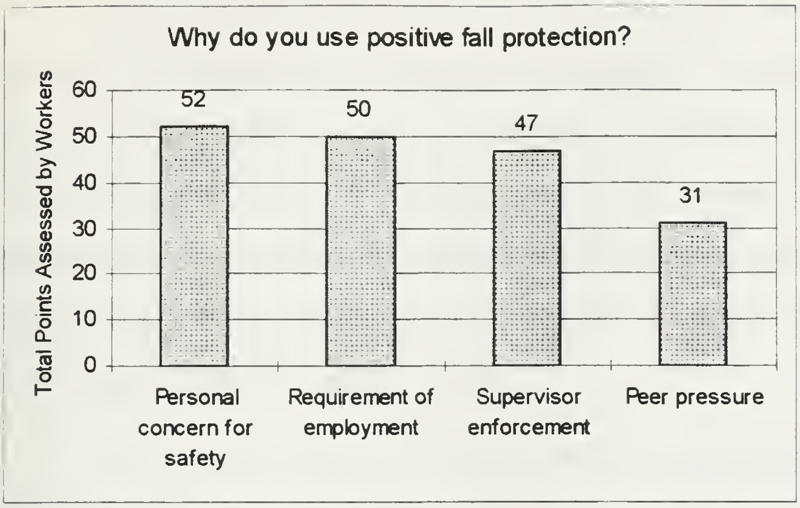

Figure 4.16: Reasons for worker compliance, as rated by workers

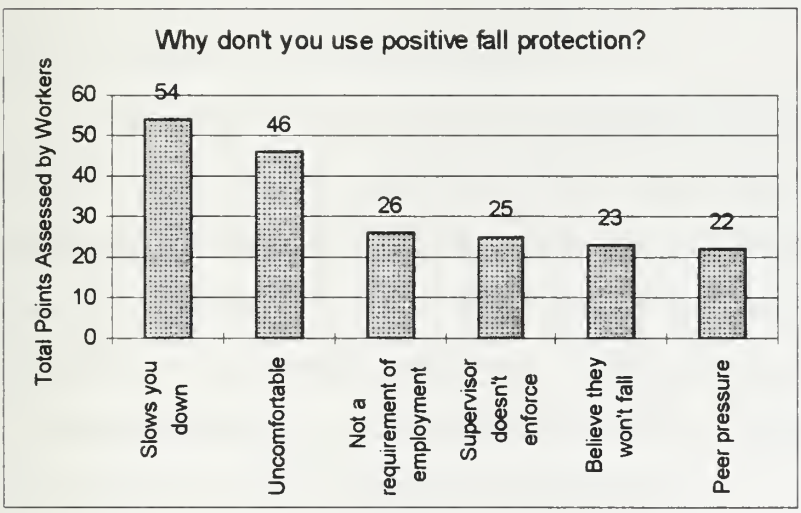

Figure 4.17: Reasons for worker non-compliance, as rated by workers

Reasons given for non-compliance, on the other hand, were quite similar to the responses of management. The most common reason not to use fall protection is productivity-related. The second reason given was that it was uncomfortable. However, the next two reasons were not worker-centered, as the managers had thought; instead, they were due to management's shortcomings--that using protection was not a requirement of employment and that supervisors did not enforce its use. Still, correlation between the two populations' responses to this question was quite high, at $r = 0.78$.

These results once again emphasize that the workers do not appear to have adopted a confrontational stance, even though the construction managers might have. The managers are saying that the workers are a source of the problem and that the managers have the key to the solution. The workers, while acknowledging management's attempts to solve the problem, still believe that management can do more. However, they also acknowledge that their own behavior may be a source of non-compliance as well.

4.3.8 Actions to Increase Worker Protection

The final question on the survey involved possible actions for increasing worker protection. The most popular solutions mentioned by the managers were listed in question #12, and the workers were asked whether they felt the proposed solutions would encourage or discourage compliance. The responses were assessed points on a Likert scale, where "strongly encourage" = +2, "somewhat encourage" = +1, "neither encourage nor discourage" = 0, "somewhat discourage" = -1, and "strongly discourage" = -2. The mean responses for each proposed action are given in Figure 4.18 (following page).

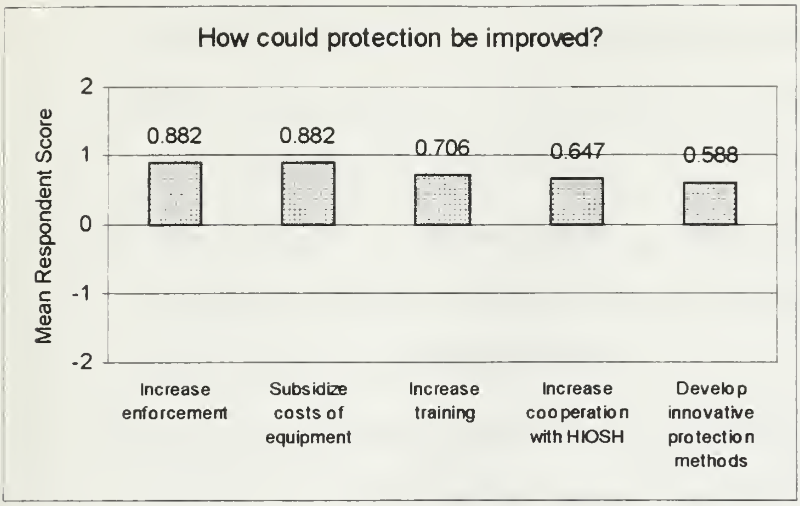

Figure 4.18: Actions for increasing worker protection, as rated by workers

The primary solutions according to the workers were to increase enforcement and to subsidize costs of fall protection equipment. Increasing training was considered to be an important option as well, but not the primary option, unlike the managers. The workers felt that increasing cooperation with HIOSH and developing innovative methods of protection would also encourage compliance. The workers were not overly enthusiastic about any of these methods, however. Each of the mean scores for the proposed actions were below "somewhat encourage." Because no particular method is more recommended than another, it can only be said that a broad-based approach should be taken to encourage compliance and increase worker protection.

4.4 Summary of Findings

The findings from the interviews with union officials and the worker surveys can be summarized as follows:

(1) Labor believes that the level of compliance is moderate at best. Labor seems to face less problems than managers in complying with regulations. Those problems that they do face appear to be management-centered, not

worker-centered. The principle reason given by labor for non-compliance was productivity-related. Other problems included worker behavior, design issues, a lack of regulatory oversight or other form of external supervision, a lack of equipment, and a lack of training.

(2) Labor prefers to use a passive protection system over one requiring active participation. Alternative systems are not believed to afford workers the same protection as conventional systems.

(3) Labor and management's familiarity with various fall protection systems is quite similar (r = 0.96); both have primarily utilized PFAS and the fall protection plan. Workers have most often used PFAS in sheathing and roofing, and the plan during truss installation and sheathing. Workers and managers have different opinions as to how best to protect workers during various phases of construction, especially during truss installation (r = 0.15) and low-sloped roofing applications (r = 0.27).

(4) Nearly one-fourth of workers has witnessed a fall accident in the past three years. Of those accidents, 14% resulted in permanent disability, and another 28% in fractures, underscoring the seriousness of falls in residential construction.

(5) Workers often use positive protection, and the vast majority (79%) feels that positive protection is required above roof slopes of 4:12. There is a large difference of opinion with construction managers in this regard, as the majority of managers do not believe positive protection is required until a slope of 8:12.

(6) Bare rafters are considered to be the most dangerous roof surface by workers. This underscores the requirement for protection during truss

installation and sheathing, when workers utilize the rafters as their working surface.

(7) Workers believe that they comply with regulations out of a personal concern for their safety; this is different than managers' perceptions of their compliance, as managers felt workers complied primarily because of their enforcement of the regulations.

(8) Workers state that they do not comply with regulations primarily because the fall protection system affects their productivity or it is uncomfortable. This is quite similar to the managers' perceptions ($r = 0.78$).

(9) In order to increase worker protection, labor recommends increasing oversight and enforcement, increasing training, and increasing cooperation between HIOSH and contractors. However, there was a wide range of opinions as to how best to increase protection, indicating that only a broad-based approach will solve the problems faced by workers and contractors.

4.5 Labor's Requirements

The information obtained from the interviews of union representatives and worker surveys form the basis for presenting labor's issues and interests. In developing appropriate alternative fall protection systems, the following issues and interests are paramount to workers:

(1) The system should be flexible, and applicable to conditions on site. Workers felt that systems should take into account the different phases of construction and the different working surfaces encountered during residential roof construction.

(2) The system should be passive. Systems that require workers to take an active part in protecting themselves, such as PFAS, are considered to be uncomfortable and to get in the way.

(3) The system should not affect the pace of work by slowing the worker down.

(4) The system should be easy to understand. The current regulations are too confusing and are easily misunderstood.

(5) The system should be easily obtained. Contractors make better use of "off the shelf" systems than innovative ones.

(6) The system should be easy to implement. Training should be quick and simple to ensure it is conducted and the system is correctly implemented.

(7) The system should protect them from hazards. The majority of workers felt that a positive system is required on roofs with slopes exceeding 4:12.

Each of the above requirements must be satisfied for an alternative proposal to be considered to be in the interests of the workers. Since the intent of these regulations is to protect the workers, their interests should be taken into account when developing alternative proposals. These alternative proposals will be presented in Chapter 6.

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Mactagone, Denis (1997). Training Coordinator, Carpenters Union Local 745. Interview. Honolulu, HI. February 13.

Chapter 5: Enforcement's Views

5.1 Methodology of Investigation

The last party to be investigated was enforcement--OSHA and HIOSH. This investigation involved two sub-steps:

(1) Review of case histories

(2) Interviews of compliance officials from both HIOSH and OSHA

The methods undertaken for each of these steps will be reviewed below.

5.1.1 Review of Case Histories

This stage of field investigations involved a review of HIOSH citations of residential construction companies since the new Subpart M became effective in February 1995. The citations included both union and non-union contractors, involved in new construction and renovation, as shown in Table 5.1 (following page). Besides the information found in Table 5.1, each citation was reviewed to discover the following information:

(1) Activity of worker(s) at time of citation

(2) Classification of citation

(3) Proposed and abated (final) penalty

Although HIOSH records indicated that twenty residential-construction inspections resulted in fall protection citations during the period of March 1995 to March 1997 (HIOSH, 1997b), only eight cases were found to be relevant to the scope of this study. The remaining cases were either unavailable for review or were not applicable to residential roof construction and repair.

Table 5.1: Summary of case histories

Site #	Owner-ship	Number and Type of Units	Type of Construction	Stage of Roof Construction	Collective Bargaining
1	Private	One single-family home	New construction	Truss installation	Non-union
2	Private	Multiple single-family homes	New construction	Truss installation	Union
3	Private	One single-family home	New construction	Framing	Non-union
4	Private	One single-family home	New construction	Truss installation	Non-union
5	Private	Multiple single-family homes	New construction	Sheathing	Non-union
6	Private	One single-family home	Renovation	Truss installation	Non-union
7	Private	One single-family home	New construction	Truss installation	Union
8	Public	Multiple condominium units	New construction	Roofing application	Union

5.1.2 Interviews of Enforcement Officials

Interviews were obtained with the staff of HIOSH and OSHA's Program Manager for Subpart M. The interviews were aimed to gather enforcement's views on the following issues:

(1) The current state of compliance and enforcement, and factors leading to non-compliance

(2) Existing methods of protection, especially enforcement's perspective with regard to the protection offered by existing methods

(3) Possible actions to increase worker protection

5.2 Case Histories

The data found through examination of the case histories were analyzed qualitatively. A database was developed to store, sort, and analyze the information obtained from the case histories. The data, given in Appendix F, were analyzed subjectively as follows.

The eight case histories reviewed indicate that HIOSH is enforcing regulations throughout the residential construction industry. The eight inspections included one public-sector job site, two private developments, and five single homeowner sites. These eight inspections resulted in eighteen citations related to failing to provide adequate fall protection.

These citations, as shown in Figure 5.1, included six for allowing workers to walk the top plate unprotected. Six employers were also cited for failing to adequately document employee fall protection training. Another five citations were given for failing to provide sufficient training. Only one citation was found for allowing employees to work on a roof unprotected. The composition of citations demonstrates that the industry practice of walking on the top plate is a major concern to HIOSH.

These citations resulted in $14,475 worth of proposed penalties, most of which were reduced by approximately 50%, contingent upon the contractor's establishment of a fall protection program and membership in one of the local contractors' associations. These fines were not assessed equally, however. The two large developers were assessed $10,950 for their citations, or over 75% of the total amount. Likewise, they paid over 75% of the total reduced, final fines.

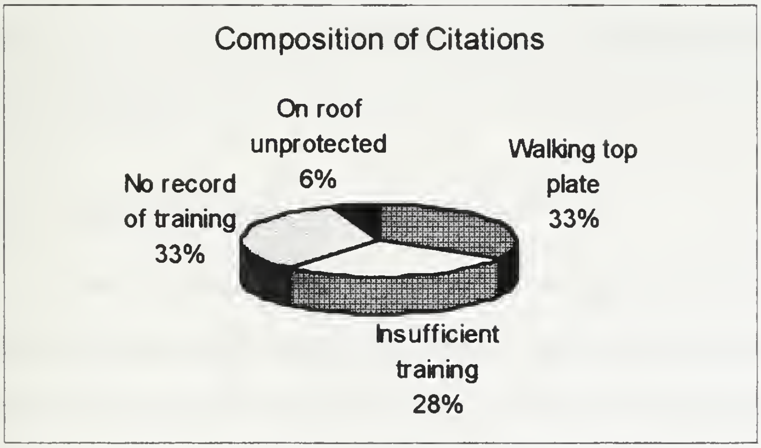

Figure 5.1: Fall protection citations for residential roof construction, as found in case histories

The average citation for the small homebuilder was $350; the average for the large developer was $1500. This indicates that although HIOSH is inspecting the smaller homebuilders, they are not assessing them the same amount in fines.

5.3 Interviews with Enforcement Officials

The information obtained from interviews with enforcement officials was also analyzed qualitatively. Notes from the interviews were first transposed into reports, which were organized along the three core issues given in section 5.1.2, above. Supplemental information was also recorded on the reports. Since only three interviews were involved, a database was not required for this analysis. Instead, a narrative analysis is given below.

Interviews and meetings were conducted with the HIOSH staff on two occasions. The first interview/meeting involved the HIOSH administrator, the heads of both the Enforcement and Consultation Branches, and project points of contact from both branches. The second interview involved only the Consultation Branch point of contact, who was at that time designing the roof jack alternative fall protection system to be used on residential roof construction.

Additionally, the OSHA Program Officer for Subpart M, Barbara Bielaski, was interviewed, to obtain the latest information from the national debate over the implementation of Subpart M in the residential construction industry. The findings of the three interviews are summarized below.

5.3.1 State of Compliance and Enforcement

The current state of compliance by the residential construction industry regarding the fall protection regulations of Subpart M is a major concern to enforcement officials. A lack of adequate fall protection is one of Hawaii's most frequently cited standards (HIOSH, 1996).

There is much confusion in the homebuilding industry as to which rule applies to any given situation, especially in roofing construction phases. This confusion has enabled some

homebuilders to take advantage of the situation, and continue on with business as usual. Business as usual involves some unacceptable practices, such as rolling trusses by walking the top plate. Other factors leading to non-compliance include competitive pressures (production takes precedence over safety) and worker behavior (HIOSH, 1996).

Increased enforcement is not possible, not without an increased budget, which appears highly unlikely to occur anytime soon. Additionally, the small homebuilder and maintenance sectors are characterized by rapidly changing schedules, such that enforcement is almost impossible. Therefore, the officials desire to move from strict enforcement to voluntary compliance (HIOSH, 1996).

5.3.2 Adequacy and Use of Fall Protection Systems

HIOSH believes that the interim guidelines for residential construction found in OSHA Instruction STD 3.1 do not afford equal protection to the workers, and are therefore unacceptable (HIOSH, 1996). OSHA is also uncertain about the effectiveness of the new alternative fall protection systems allowed by Subpart M and STD 3.1 (Bielaski, 1997).

As for conventional fall protection systems, contractors have informed HIOSH that these systems cause a greater hazard, are infeasible to implement, and/or are not utilized by the workers (HIOSH, 1996). Therefore, HIOSH has commissioned this study in an effort to find a system or systems which are feasible, while affording equal protection to those found in Subpart M.

5.3.3 Actions to Increase Worker Protection

The sole action to increase protection that has been proposed by enforcement officials is the combination roof jack and fall restraint system that was described in Chapter 2. This method is currently being reviewed by Roofers Local 221 and by the Hawaii Roofing Contractors' Association (Thorp, 1997).

5.4 Summary of Findings

The findings from the interviews with enforcement officials and the case histories can be summarized as follows:

(1) Unsafe, conventional construction methods such as "walking the top plate" are considered by HIOSH to be a primary cause for concern. As such, HIOSH has concentrated its enforcement efforts towards eliminating this practice.

(2) The fines for failing to provide adequate fall protection are fairly low, between $350 and $1500 per citation.

(3) Worker behavior, competitive pressures, and confusion over implementation of Subpart M all contribute to the current state of non-compliance.

(4) Current fall protection methods are deemed to be inadequate, as contractors find conventional methods infeasible and enforcement finds alternative methods unprotective. Therefore, new methods must be discovered and analyzed for their ability to meet both contractor demands and enforcement's requirements.

5.5 Enforcement's Requirements

The information obtained from the case histories and interviews form the basis for presenting the regulatory agenda. In developing appropriate alternative fall protection systems, the following issues and interests are paramount to enforcement officials:

(1) The system should be self-regulating. The key is to develop a system which will allow for voluntary compliance as opposed to strict enforcement.

(2) The system should be passive. Systems that require workers to take an active part in protecting themselves, such as PFAS, are considered by the workers to be uncomfortable and to get in the way. Because of this, they are often cited as creating a greater hazard.

(3) The system should be feasible to be implemented by all contractors using standard construction methods. For example, it should not require use of equipment that is not normally found on the job site.

(4) The system should not be difficult to understand nor to implement. The current regulations allow for too many interpretations, and are incomprehensible to most contractors and workers.

(5) The system must protect the worker to at least the same degree as Subpart M.

Each of the above requirements must be satisfied for an alternative proposal to be considered to be in the interests of enforcement officials. Since enforcement will be responsible for changing any regulations and/or approved guidelines for fall protection, their interests must be taken into account when developing alternative proposals. These alternative proposals will be presented in Chapter 6.

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HIOSH (1997b). Custom report of fall protection citations for residential construction, 3/1/97 to 3/21/97.

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Chapter 6: Proposed Fall Protection Systems for Hawaii's Residential Roof Construction Industry

In Chapters 3 through 5, the views of the various parties in residential roof construction's fall protection debate were presented. This chapter will summarize those views, draw criteria for fall protection systems from those views, and analyze several possible systems for their ability to meet these criteria.

6.1 Fall Protection Systems Criteria for Residential Roof Construction

The requirements of the various parties for a fall protection system for use in residential roof construction were found in Chapters 3-5. These requirements include:

(1) All three parties feel that the system must be implementable and feasible. The *degree of feasibility* is the degree to which the system doesn't require unusual equipment, expensive materials, or specialized labor to implement.

(2) All three parties also believe that the system must be simple. The *degree of simplicity* is the degree to which the system does not require any specialized knowledge/training to implement.

(3) Each of the parties also indicated that the system should offer the workers passive protection. The *degree of passivity* is the degree to which the system does not require worker involvement.

(4) The contractors felt that the system must be economical. Enforcement also felt that the system's benefits must exceed its costs in order for the system to be self-regulating. Even labor felt that the system must not affect productivity. Therefore, each party felt that the system must in some way be economical. The *degree of economy* is the degree to which the system's benefits exceed its costs.

(5) Contractors and labor expressed their opinions that the system should be flexible, and adaptable to varying site conditions. The *degree of flexibility* is the degree to which the system can be applied in the various circumstances found in residential roof construction--both for the different stages of construction and for various slopes, shapes, and materials of roofs.

(6) Finally, labor and enforcement require that the system must protect the workers. The *degree of protection* is the degree to which the system protects the workers from fall hazards, as compared to the requirements of Subpart M.

These six basic criteria must be met if a system is to be accepted and implemented on a wide-scale basis in Hawaii's residential roof construction industry.

6.2 Proposed Actions to Increase Worker Protection

Various solutions to the fall protection dilemma were likewise found and presented in Chapters 3-5. These solutions are outlined in Table 6.1.

Table 6.1: Actions for increasing worker protection

Proposed Solutions	Recommending Party		
	Contractors	Labor	Enforcement
Develop innovative methods of fall protection	X	X	X
Increase training	X	X	
Subsidize costs	X	X	
Increase cooperation with HIOSH	X	X	
Change the safety culture	X	X	
Increase regulatory or owner oversight	X	X	
Increase involvement of risk managers	X		

As shown in Table 6.1, developing innovative methods of fall protection was considered to be one possible action to improve worker protection by each of the three parties. The remainder of this chapter will be devoted to analyzing some innovative methods, including alternative construction and design methods, which were discovered through the interviews and job site visits discussed in Chapters 3-5.

The remaining actions given in Table 6.1 will not be evaluated, as they do not comprise the fall protection system itself; rather, they are part of the environment in which the system operates. Nevertheless, these options will likely contribute to improving worker protection, and will be discussed further in Chapter 7.

6.3 Analysis of Discovered Fall Protection Systems

Several innovative and conventional methods of protecting workers from falls were discovered during job site visits and from interviews. The more promising of these include:

(1) Guardrail systems as shown in Appendices A and B,

(2) PFAS variants, including a roof truss anchor system and the Safe-T-Strap™ system, both shown in Appendix A,

(3) Combination warning line/lifeline system, described in section 2.5,

(4) Fall protection plans, found in Appendix C,

(5) Roof jack/positioning device system proposed by HIOSH, described in section 2.5,

(6) Use of scaffolds and/or work platforms to eliminate fall hazards, and

(7) Prefabrication of roof systems on ground, followed by lifting into place, as shown in Appendix B.

Each of these alternatives was analyzed to determine their ability to meet the six criteria listed in section 6.1. To ensure objectivity and a methodological approach to the analysis, a system analysis form was developed, as shown in Figure 6.1 (following page). The form is organized along the lines of a job hazard analysis, the standard tool for safety analysis in the construction industry.

The first section lists the resources required to implement the system on a typical home. The following typical home dimensions were utilized:

48 ft long x 30 ft wide gable roof with an 18 ft eave height and 2 ft eave overhang

Vaulted ceiling in one corner: 17 ft long x 15 ft wide

Additionally, material and equipment needs were based on protection of two workers.

The labor, equipment, and material information were obtained from the construction manager or enforcement official who proposed or used the system, hereafter referred to as the system's sponsor. The degree of feasibility was assessed based on the availability of those resources to the typical contractor.

Requirements for training on the system were assessed by a local safety training provider, Safety First, and the researcher. The amount of training required was used to assess the degree of simplicity of the system.

Finally, the costs of the resources--labor, equipment, materials, and training--were combined to find the overall cost of the system. The costs were obtained using prevailing wages for residential construction workers in Hawaii and from local suppliers of material, equipment, and training. These costs were then used to assess the system's degree of economy.

Worker involvement was assessed based on the system's operation only, after initial installation. Worker involvement was determined from interviews with the system's sponsor. The degree of passivity was assessed based on the degree of involvement; high involvement equates to low passivity.

RESOURCES REQUIRED TO IMPLEMENT					
Labor / Materials / Equipment	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2
Training	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2
Costs	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2
Degree of Flexibility: _____ (Mean)					

WORKER INVOLVEMENT	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Figure 6.1: Fall protection system analysis form

The system was then analyzed based on its applicability to the various stages of construction and the various surfaces and shapes encountered in residential roof construction. These assessments were made based on the interviews with the system's sponsor. The system's overall degree of flexibility was then found by the mean of the applicability scores.

Finally, the amount of protection afforded to the worker during system operation was assessed. Following the interviews with the system's sponsor, the operation of the system was compared to the requirements of Subpart M. The degree of protection was assessed based on the comparison.

Each of the following systems was analyzed using the system analysis form. The resulting forms are provided in Appendix G, and discussed below.

6.3.1 Guardrail System

This method of protection is one of the conventional methods allowed under Subpart M for residential roof construction. It was utilized on two job sites, and several more construction managers had employed it on one or more occasions. One of the two job sites involved a job-site manufactured guardrail, used during siding operations, as shown in Appendix B. This guardrail system could not be utilized for actual roof construction, as it connected to the deck and impeded roofing. The other job site utilized the PR20 Eave Catchguard system shown in Appendix A. This system involves the use of fabricated stanchions that connect to the deck of the roof using rafter brackets. The roofing material can be applied over the brackets, which can be removed following completion of the job, similar to the brackets used to hold roof jacks.

The system analysis form for the guardrail system is shown in Appendix G. Required resources are basic except for the stanchions themselves, which cost $24 each from the mainland distributor, including shipping and handling (Roofmaster Products, 1997). The feasibility is therefore only somewhat feasible, as many contractors do not know of this system.

Training on this system consists only of a basic introduction to guardrail installation and maintenance, particular to this system. Estimated training time is only two hours. Because this system can be used on any slope, and it uses standard rafter brackets for attachment, the system is very simple.

The costs for this system are fairly high, at $780 total. Most of the cost is due to the stanchions and the 2" x 6" planks that are used as guardrails/toeboards. Therefore, most of the costs can be recouped over several projects. However, the relatively large up-front cost will make this system somewhat uneconomical for Hawaii's home builders.

This system cannot be used during truss installation, as there is nowhere to place the brackets. Likewise, it can only be used during sheathing after the first row of sheathing is placed. Additionally, this system will not protect the workers from falls through the rafters, which is considered to be the most dangerous roofing surface by workers. The system is most applicable to roofing application, and is able to be used on any roof shape and slope, and for most roof surfaces. However, the guardrails--like roof jacks--are only placed on the rake edges of the roof, leaving the gable edges unprotected. Since most falls occur from the rake edge, even on a gabled roof, this system is still mostly applicable to gable roofs. Because the rafter brackets attach to the roof deck, and are removed after roofing is complete, only certain materials can be placed on top of them. Metal roofing would interfere with the ability to remove the roofing brackets following completion; therefore, this system is not applicable to metal roof surfaces. For finish work on the roof itself, this system is still highly applicable; however, for fascia installation or other finish work on the eaves, this system is not applicable. The overall flexibility of the system, determined by the mean of the applicability scores, is 0.92.

For the most part, the workers using this system do not need to be involved in their own protection, once the system is installed. The exception to this is when working along a gabled edge, when the worker must be aware of the fall hazard and ensure he or she does not take any

risks in the area of the edge. Overall, this is a low amount of involvement, especially on hip roofs, where the entire perimeter of the roof can be protected with the guardrail system.

The guardrail system offers passive, positive protection to workers from falls off the rake edges of the roof. Although it offers no protection from falls off gabled edges, nor from falls through roofs, these hazards are not as large as the hazard from the rake edge. Still, Subpart M does not state that gabled edges can be unprotected; therefore, this system offers substandard protection.

6.3.2 PFAS Variants

There were two promising innovations observed with PFAS. Both variations are due to unique anchorages. The first, a roof truss anchor system, was utilized on two job sites visited. The system is described in detail below, and graphics are included in Appendices A and B. The second system is the Safe-T-Strap™ system, developed by a Canadian firm, Liberty Safety Products. This system was observed in use on one job site. Graphics are included in Appendices A and B.

6.3.2.1 Roof Truss Anchor System

The roof truss anchor system involves the installation of one or more anchors on the truss framework. The anchorage can be installed before, during, or after truss installation, depending on the system used. There are several types of anchorage points available; four of these are included in Appendix A. DBI/SALA offers a u-bolt roof anchor, which is designed to be permanently installed as a part of the finished roof system. A permanent, bracket-type anchor, designed for use on roof peaks, is manufactured by Guardian Metal Products. Known as the Trus-T anchor system, this type of anchor was installed at one construction site visited. The SINCO Group offers a temporary bracket-type anchor. DBI/SALA also offers a bracket-type anchor, only with a detachable feature, so that the swiveling anchor point can be removed, leaving the bottom assembly behind. This eliminates the need to "work around" the anchor point.

This type of anchor was found on the other job site. Each of these systems has one thing in common–it is connected to a truss, either before, during, or after truss installation.

Resources required for the roof truss anchor variant include the full PFAS assortment, plus the roof truss anchors. For purposes of this analysis, shown in Appendix G, the anchor chosen was the Trus-T roof anchor, which costs $22 from a local distributor (Safety Systems Hawaii, 1997). This system is available locally, and most contractors already utilize PFAS to some extent. Therefore, this system is highly feasible.

Only three hours of training are required for this system: two in PFAS use and one in the situational use of the Trus-T anchor. Therefore, this system is somewhat simple.

Costs for the system are quite low at $420. Since most contractors already utilize PFAS on their job sites, the costs decrease to just the cost of the Trus-T anchor system. Even those contractors who have not used PFAS may find that the system is somewhat economical.

Like all PFAS, this system is not applicable to truss installation, as it cannot be considered a suitable anchor point until the trusses themselves are braced. However, it is mostly applicable during sheathing and highly applicable for almost all roofing applications and finish work. The only exception is metal roofing, where this system would interfere with the proper roofing application. The overall flexibility of the system is therefore quite high, at 1.25.

This system requires frequent worker involvement to maintain protection. First, the worker must attach his or her lanyard to the lifeline that is attached to the anchor. Also, as the worker moves along the roof, he or she must adjust the length of the lanyard by adjusting his or her rope grab as required. As found during job site inspections, this is a task often overlooked by workers as they move from place to place on the roof. However, the worker is fully protected from all fall hazards while properly using this system. Therefore, this system offers a very high degree of protection to the workers.

6.3.2.2 Safe-T-Strap™ System

The Safe-T-Strap™ system is another variant of the standard PFAS. In this system, shown in Appendix A, the anchor is a 2" wide strip of nylon webbing which has a D-ring on one end. The free end is nailed and wrapped around a member of the house frame. The procedure for installation varies according to the member used. For a roof truss and the top plate of a frame wall, the strap is attached to the top of the truss or wall with two nails, then wrapped once around the member, and finally a third nail is driven through the strap. For a floor joist, the strap is just attached to the joist with four nails. The lanyard of the PFAS is attached to the D-ring of the strap, and connects to the worker's harness. This system was observed in use on one job site. Photographs are included in Appendix B.

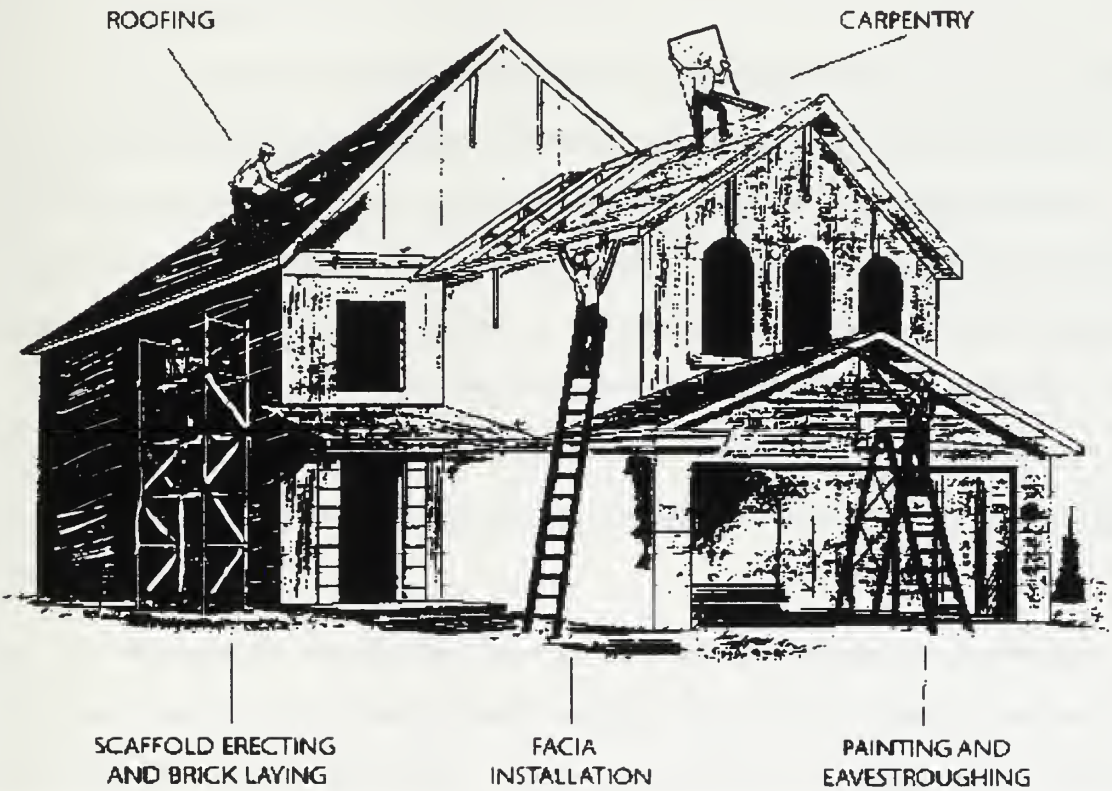

Figure 6.2: Safe-T-Strap™ use in residential construction (Source: Liberty Safety Products, 1997)

This anchor system is designed to be installed at various points around the house, allowing the workers to transfer from one anchor to the other as required. Figure 6.2 (preceding page) shows the manufacturer's concept for the use of Safe-T-Straps™ in residential construction. Following completion of the house, the final user of the strap can cut the strap off with a sharp knife, so that nothing is exposed on the exterior of the home following construction.

The Safe-T-Strap™ system is also analyzed in Appendix G. Because it is also a PFAS variant, there is not much difference between this system's analysis and that of the roof truss anchor system. The only difference is in the resources. Instead of using roof truss anchors, this system uses Safe-T-Straps™. The cost of the straps is $105 for a box of fifteen (Liberty Safety Products, 1997). Thus, the overall cost of this system is $390.

6.3.3 Combination Warning Line/Lifeline System

This system is a composite of the PFAS and warning line system. As such, it is a hybrid conventional and alternative fall protection system. Used on a job site in Kona, this system involves the installation of roof anchors six feet from the roof edges. This particular job site allowed approximately 30 ft between anchors; however, Subpart M requires that the anchors be placed no more than 15 ft apart for lifeline use. The lifeline--made of synthetic line or wire rope--is looped through each roof anchor. When the workers are above the line, they are able to walk freely, without any protection. As soon as they cross the line, the workers attach their lanyards to the lifeline, allowing for freedom of motion in the horizontal direction while they are working at the roof's edge.

The analysis form in Appendix G shows that this system requires relatively little new resources. Most contractors will have these resources readily available; therefore, this system can be considered to be highly feasible. Training in this system is somewhat simple, involving one hour of training on the warning line/lifeline and two hours on the PFAS. Because of the sheer amount of roof anchors required (10 total), the costs are slightly uneconomical, at $540.

Like other PFAS, this system is not applicable to roof truss installation. It can be used for low-sloped roofing application. This system is not authorized for use during sheathing nor steep-sloped roofing application. Although theoretically, this system can be used effectively on both hip and gable roofs, this system is somewhat intrusive, with the amount of roof anchors required. The roofers would need to roof below and above the anchors and lifeline, then remove the system in order to finish the project. Because the anchors would need to be removed prior to completion of roofing, this system is also not applicable to finish work. This system's flexibility is quite low at -0.50.

To ensure that he or she is protected, the worker must sometimes get involved with this system. When he or she is above the line, the worker can work unimpeded. Below the line, the worker must attach his or her lanyard to the lifeline, and move from segment to segment of the lifeline as required by his or her lateral movement along the edge.

If this system is used for low-sloped roofs, it results in the same amount of protection as Subpart M. While no positive protection is provided above the line, none is needed by Subpart M. Below the warning line, the system provides active, positive protection from falls; that is, the system will protect the worker from falling so long as the worker takes some action to ensure he or she is protected (i.e., tying off).

6.3.4 Fall Protection Plan

Fall protection plans were widely used on many job sites. Three such plans are included in Appendix C. Plans do not comprise a fall protection system, in and of themselves. Instead, each plan outlines its own specific system(s) for use on the job site. The three plans included in Appendix C show the variety of systems used under a "fall protection plan."

Plan #1 includes the use of controlled access zones (CAZs) and details "safe work practices" to be used during truss installation, floor joist and sheathing, and exterior wall erection. The safe work practices outlined in this plan, however, are no different than those traditionally used and described in section 2.3. Additionally, the method of identifying the CAZs is left to the job site competent person, who is not identified anywhere in the plan.

Plan #1 only covers one phase of residential roof construction--truss installation. Roof sheathing, roofing application, and finish work were all to be accomplished using conventional fall protection systems on this project. The plan is supposed to identify methods of protecting workers from falls. For those workers walking the top plate, the plan "protects" the workers by limiting the number of workers exposed, ensuring adequate bracing of frame prior to truss installation, and requiring workers to use previously erected trusses as supports and only leave those trusses when necessary to get the next truss. In essence, this plan does not provide any protection to the workers who are walking the top plate. For workers bracing the trusses at the peaks, the methods of protection are contradictory. First, the plan states that these workers will use PFAS. Then, it says that they will be protected by limiting the number of workers and by requiring them to "work from a stable position, either by sitting on a 'ridge seat' or other equivalent surface." The plan is silent as to when the worker will use PFAS or the plan. Therefore, this plan offers very low protection for the workers in the ridge of the truss.

Plan #2 is a roofing company's fall protection plan. It only covers roofing application. This plan is actually not required, since the plan states that PFAS will be used on the job site. There are no instances provided for the use of other systems. It appears, then, that this plan is superfluous. When a conventional system is used, a fall protection plan is not required.

Like Plan #1, Plan #3 covers truss installation. The methods of protection for workers involved in truss installation include a safety monitoring system, a CAZ, and limiting and training workers who are involved in this phase of work. However, this plan does not identify the specific

work practices to be used on this site, leaving it up to the crew. Therefore, the work practices chosen could include walking the top plate and working from the ridge.

The three plans show the range of protection afforded by the fall protection plan. If done correctly, the plan can eliminate or reduce most fall hazards, and can provide adequate protection for workers exposed to other hazards. However, if not properly written, the fall protection plan can be confusing and offer little or no additional protection to the workers involved in the process.

Appendix G provides the system analysis for the fall protection plan. Resources required to write a plan are simple, involving only overhead staff time. However, the training required for the drafter to be adequately versed in fall protection is quite extensive. One estimate placed it at three days. Unfortunately, this also makes the plan uneconomical. However, a fall protection plan affords the greatest degree of flexibility, as it can account for job-site specific concerns.

As seen in the plans in Appendix C, the degree of worker involvement and the degree of worker protection are dependent upon the actual fall protection systems required by the plan. Since each plan can use its own systems, these criteria cannot be assessed.

6.3.5 Roof Jack System

This method is HIOSH's proposed system to improve worker protection and contractor compliance. As described in section 2.5, this system involves the use of roof jacks, either solely or in conjunction with a positioning device system, as outlined in Table 6.2.

Table 6.2: Roof jack and positioning device system requirements

Condition	Slope	Eave Height	Requirement
1	Less than or equal to 6:12	Less than or equal to 25 ft	Roof jacks only
2	Greater than 6:12	Less than or equal to 25 ft	Roof jacks and positioning device system
3	Greater than 6:12	Greater than 25 ft	Conventional fall protection system

Like the previous systems, the roof jack and positioning device system was analyzed using the system analysis form. The three resulting forms are included in Appendix G--one for each roof slope/eave height combination, as shown in Table 6.2. Resources required to implement the system are very basic--2" x 6" planks, brackets, and nails for the roof jacks alone, add PFAS components (harness, lanyard, anchor) for slopes exceeding 6:12. No specialized labor or equipment is required for installation. Under conditions 1 and 3, this system is highly feasible; however, the resources required for positioning device use make this system only slightly feasible under condition 2.

Although only one hour of training is required to adequately instruct workers in the installation and use of the roof jacks, more training (approximately two hours) would be required for positioning device and PFAS use. Workers would need to be instructed in both the differences between positioning devices and PFAS, and the appropriate use of each of the possible systems; this situational use training would require another hour. The potential for worker confusion is therefore fairly high, and this system can be considered slightly complex.

Costs of this system are relatively inexpensive when looking at condition 1. For a 50 ft long gable roof, material costs are $150. Labor costs to install and remove roof jacks are $70. For condition 2, the material costs increase dramatically, by $1850. This increase is due primarily to the cost of retractable lanyards. As mentioned in section 2.4, to keep the fall distance below 2 ft, as required by positioning device systems, workers would usually use either a short lanyard or a self-retracting lanyard. However, as discussed in section 2.5, since the workers require mobility, a short lanyard would be infeasible in roofing operations. Therefore, a self-retracting lanyard is the only feasible option.

The roof jack system alone is somewhat economical. However, under condition 2, the system becomes uneconomical. In fact, the economy improves under condition 3. This condition only allows the use of a conventional PFAS, which would not require a self-retracting lanyard. Conventional PFAS, as discussed above, are quite economical. Because of the extra training

required for the overall system, however, PFAS use under the roof jack system is slightly uneconomical.

Under all conditions, this system is not applicable to truss installation, as the fall hazard is through the rafters rather than off the edges, and as there is no anchor point for the positioning device system or PFAS. For sheathing applications, this system will only afford protection from all falls if the slope exceeds 6:12 (conditions 2 and 3), when the workers would be required to utilize a positioning device system or PFAS. The positioning device system could likewise reduce the hazards of swing fall which reduce the effectiveness of PFAS during sheathing operations. Under condition 1, the worker would only be protected from falling off the rake edges of the roof, so it is only moderately applicable to sheathing operations.

For roofing application, this method somewhat accounts for the increase in danger due to increasing slopes. Since workers did not believe that positive protection was required below 4:12, this system is highly applicable to such circumstances (condition 1). For roof slopes above 4:12 but less than or equal to 6:12 (still condition 1), this system is only somewhat applicable, as workers preferred positive protection under such circumstances, according to the survey. Condition 1 was not evaluated for slopes exceeding 8:12, as its use is not allowed in this situation. Similarly, conditions 2 and 3 were not evaluated for slopes below 6:12. For both conditions, the system was highly applicable for slopes exceeding 6:12.

Since roof jacks are not required along gabled edges, this system is not effective in protecting workers from falls off the gabled edges of roofs under condition 1. However, the fall potential is relatively small from the gabled edge (Thorp, 1997), and thus this is not the major concern for these roofs. Therefore, this system is mostly applicable for use on gable roofs under condition 1. For hip roofs, each edge is protected, so this system is highly applicable for use on hip roofs. Under conditions 2 and 3, the worker is protected by the positioning device system or the PFAS, and therefore, this system is highly applicable for both gable and hip roofs under these conditions.

Like the guardrail system described in section 6.3.1, this system in conditions 1 and 2 requires the use of rafter brackets that are installed on the sheathing prior to roofing installation. The roofing material is applied over the brackets, which are removed following roofing. This method is thus not applicable for metal use, as metal cannot be installed over the brackets. However, it is highly appropriate for the asphalt shingle, cedar shake, and clay or slate tile roofs that are so common to Hawaii. In condition 3, the roof jacks are unnecessary. However, the PFAS anchor point becomes a problem, so that this system is still inappropriate for use on metal roofs under condition 3.

Because the roof jacks can remain installed even after roofing application is finished, this system can be used during certain finish-work tasks under condition 1. However, fascia installation would not be included, as the roof jacks are installed 2-3 ft from the roof's edge. The fascia, of course, is installed at the roof's edge. Because applicability for finish work is task-dependent, this system is only moderately applicable, at best, under condition 1. Under conditions 2 and 3, the worker is protected by the positioning device system or PFAS, so the problems encountered during finish work are a result of the anchor point. The anchors typically used would be standard "tin lizzy" roof anchors, which attach to the sheathing at the roof's peak. These anchors must be removed prior to the installation of the roof cap. Thus, the applicability to finish work under these conditions is dependent upon the anchor system used, and is therefore only applicable if modified.

The overall flexibility of the system can be determined by the mean of the various applicability scores. For condition 1, the flexibility was determined to be 0.64. For condition 2, it was 1.00, and for condition 3, 0.91. Overall, it appears that the system is quite flexible.

Once installed, the roof jacks alone (condition 1) only require worker involvement in preventing falls off the gabled edges, and when the worker is working below the roof jacks. If used in combination with a positioning device system (condition 2), this system requires no worker involvement, since the self-retracting lanyard will protect the worker at all times, so long as

he or she initially hooks it up to his or her harness. Another benefit of using the positioning device (vice PFAS) on steep roofs is that the worker can hook up to the front or side of the harness instead of the back, enabling him or her to work more quickly and with less interference. Under condition 3, the system requires frequent adjustment, like all PFAS, and therefore is not passive.

The protection issues mentioned in the discussion on applicability are a cause for concern with this system under condition 1. Workers are not positively protected, even from falls off rake edges, with roof jacks alone. Once the positioning device system or PFAS is required (conditions 2 and 3), worker protection increases dramatically.

For slopes below 4:12, Subpart M allows the use of a warning line system during roof application. The roof jack system's protection exceeds that of the warning line system, as it could stop the slide of a worker and thereby prevent his or her fall off the edge of the roof. However, at slopes above 4:12, Subpart M requires that workers be protected with one of the conventional fall protection systems, unless the employer can demonstrate infeasibility or greater hazard, in which case he or she may implement a fall protection plan. Thus, for slopes between 4:12 and 6:12, the degree of protection offered by the roof jack system is below the standards set in Subpart M. Overall, this system under condition 1 offers substandard protection. Under conditions 2 and 3, this system affords the worker a great degree of protection.

6.3.6 Scaffolds and Work Platforms

As discussed in section 2.6, the concerned employer will protect his or her workers from falls by following the hierarchy of fall protection, which starts with elimination of the fall hazards altogether. One method of eliminating the fall hazard is to work from scaffolds and platforms in order to reduce the fall height under the 6 ft limit. The use of work platforms and/or scaffolds was observed on two job sites visited; both were Department of Defense projects. Work platforms or scaffolds were used on both sites during truss installation, by placing work platforms or scaffolds

inside the second-story exterior frame walls. The work platforms typically do not exceed 3 ft in height, and can be fabricated out of common construction materials. The most common platform observed was the "sawhorse scaffold," which involved two or three 2" x 12" nominal planks, placed side by side on top of two standard sawhorses. The worker was elevated approximately 3 ft from the deck. For the typical worker, this platform placed his or her chest at the height of the top plate, allowing him or her to easily set and brace the trusses at chest height while walking and working on the platform. Since the exterior walls were already framed in, the worker could use these walls as required to maintain his or her balance and to prevent falls to the ground below. Because the platform is less than 4 ft in height, it is not considered a scaffold under Subpart L; consequently, the interior side of the platform requires no guardrails.

In order to use scaffolds or work platforms during truss installation, the sequence of construction must be slightly altered as shown in Figure 6.3. As described in section 2.3, the typical sequence of construction is to frame both the exterior and interior second-story walls prior

Activity	Manpower Required	Days												
		0	1	2	3	4	5	6	7	8	9	10	11	12
Frame 2nd story exterior walls[a]	2	■	■											
Load trusses	2			■										
Set & brace trusses	2				■	■	■							
Roof sheathing	2							■	■					
Frame 2nd story interior walls	2									■	■	■		
Fascia installation	1												■	
Roof loading	1												■	
Roof installation	2													■

Notes:

[a] Denotes 2nd story walls which are separate from the 1st story exterior wall system. There are places on a typical single family home where the exterior walls extend from the foundation to the roof system. Those walls are framed in with the 1st story exterior walls.

Figure 6.3: Modified construction schedule for building the roof system of a new home when using scaffolds and/or work platforms during truss installation

to truss installation. To allow room for the work platforms, most of the interior second-story walls cannot be installed until truss installation is complete. Since the framers who are installing the interior walls should not be exposed to falling objects while working, these sites did not allow interior wall framing until roof sheathing was complete.

For the typical home described above, having a small vaulted ceiling area, this system is neither very feasible nor economical, as it would require the use of scaffolds in the vaulted area. However, for those homes without vaulted ceilings, this system could be economical. The resources required for implementing this system on the home described above are rather extensive, including 11 pairs of sawhorses, 22 2" x 12" planks, and a rented scaffold 30 ft long and 14 ft high, which can be rented for $190 per month (Atlas Sales Company, 1997). Training is extensive for scaffold erection, such that the system can be considered to be somewhat complex. Costs are very high, primarily due to the high cost of training, making this system uneconomical.

This system is highly applicable to truss installation, but only applicable to the others if modified to include exterior scaffolding. The overall flexibility of the system is low, at -0.83. One of the main advantages of this system, however, is its high passivity. Once the system is installed, no worker involvement is required to maintain 100% protection. Likewise, the protection afforded by this system is unsurpassed, as the fall hazards are eliminated.

6.3.7 Prefabrication

Another method of eliminating the fall hazard is through prefabrication. Prefabrication of the roof system on the ground was used on one job site in central Oahu. Photographs of the prefabricated roof systems, ready for lifting, are shown in Appendix B. This builder only utilized prefabrication for the truss system; sheathing and roofing application were accomplished after the truss system was lifted into place. The sequence of construction is thus altered as shown in Figure 6.4 (following page).

Activity	Manpower Required	Days									
		0	1	2	3	4	5	6	7	8	9
Frame 2nd story exterior walls[a]	2	■	■								
Frame 2nd story interior walls	2			■	■	■					
Frame "top plate" system on ground	1		■								
Load trusses onto "top plate" system	2			■							
Set & brace trusses on "top plate" system	2				■	■					
Lift truss system onto walls	3						■				
Roof sheathing	2							■	■		
Fascia installation	1									■	
Roof loading	1									■	
Roof installation	2										■

Notes:
[a] Denotes 2nd story walls which are separate from the 1st story exterior wall system. There are places on a typical single family home where the exterior walls extend from the foundation to the roof system. Those walls are framed in with the 1st story exterior walls.

Figure 6.4: Modified construction schedule for building the roof system of a new home when using prefabrication for truss installation

Since the truss system is installed on the ground, there is no need for workers to walk the top plate. They can erect and brace the trusses from the ground or from short stepladders or platforms. If short sawhorse scaffolds are also erected around the interior of the house, as described above, then the workers can use them as platforms when placing the truss system onto the frame walls. The workers would thereby be positively protected 100% of the time during truss installation. Fewer sawhorse scaffolds would be required as well, as worker movement would not be as extensive as when rolling trusses.

As shown in Figure 6.4, prefabrication of the truss system can also result in quicker completion of the roof system. Typical roof construction involves twelve days; prefabrication could reduce this requirement to nine days, as truss installation can occur simultaneous to second-story framing. Likewise, truss installation proceeds more rapidly, as productivity increases due to the workers' ability to focus on the work instead of their poise and balance.

Estimated resources required to use this system include a small crane and four man-hours. Since most Hawaii home builders do not own their own crane, this method may not be feasible for all sites. Still, cranes can be rented at relatively low fees--$100 per hour for a 15-ton crane (Hawaiian Crane & Rigging, 1997)--so it is not infeasible for all home builders to use them.

The training required to implement this system safely includes a short crane safety awareness course for those workers who will be rigging the roof system and guiding it on top of the frame walls. Because of the training and equipment rental, the overall costs for this system are about $590. However, if the 2 man-day increase in productivity during truss installation and the overall decrease in the timeline are taken into account, the system can be somewhat economical.

Like work platforms and scaffolds, this system is highly applicable to truss installation. It is also mostly applicable to sheathing and roofing--the only requirement is that special lifting eyes must be installed if the roof system is to be complete prior to lifting. This system is probably not a good choice to use for clay or metal roofs, as the weight of the roof system would exceed most crane lifting capacities. Some finish work may be able to be completed prior to lifting, but not all. The overall flexibility of this system is 0.50.

Again, like work platforms and scaffolds, this system offers passive, positive fall protection from all hazards during prefabrication, with no worker involvement. During the lift, the workers must either use some form of fall protection or prevention when placing the roof on the frame walls. Sawhorse scaffolds could offer this protection, as could ladders.

6.4 Selection of Proposals

Table 6.3 (following page)shows the criteria scores for each of the systems described above. As shown, no single system meets every criterion. Those coming closest are prefabrication, which is slightly infeasible, and the PFAS variants, which workers describe as uncomfortable and impeding.

Table 6.3: Comparison of discovered fall protection systems

	Degree of feasibility	Degree of simplicity	Degree of economy	Degree of flexibility	Degree of passivity	Degree of protection
Guardrail system	1	2	-1	0.92	1	-1
PFAS: roof truss anchor variant	2	1	1	1.25	-1	2
PFAS: Safe-T-Strap™ variant	2	1	1	1.25	-1	2
Combination warning line/lifeline system	1	1	0	-0.50	0	0
Fall protection plan	2	-2	-1	2.00	n/a	n/a
Roof jack system, condition 1 (roof jacks alone)	2	0	1	0.64	1	-1
Roof jack system, condition 2 (roof jacks and positioning device system)	0	0	-2	1.00	2	2
Roof jack system, condition 3 (PFAS)	2	0	0	0.91	-1	2
Scaffolds and work platforms	-1	-1	-1	-0.83	2	2
Prefabrication	0	2	1	0.50	2	2

The systems were then compared using multivariate analysis. The weights of each criterion were assessed based on their importance to each of the three parties. Since the importance of the criteria is not entirely objective, only three categories were assigned: great importance, having a weight of two; some degree of importance, having a weight of one; and not important, with a weight of zero. The total importance factor was then found by summing the three parties' importance factor for each criterion. The three parties' importance scores and the total importance factor for each criterion are given in Table 6.4 (following page).

Contractors placed economy and feasibility as the criteria of greatest importance. However, they also believed that flexibility, passivity, and simplicity were important. Labor's primary concerns were for passivity and simplicity, although they were also concerned with protection, economy, flexibility, and feasibility. Enforcement felt that protection was paramount, but also believed that economy, feasibility, and simplicity were important. The total importance

Table 6.4: Relative importance of the selection criteria to each party

	Degree of feasibility	Degree of simplicity	Degree of economy	Degree of flexibility	Degree of passivity	Degree of protection
Contractors	2	1	2	1	1	0
Labor	1	2	1	1	2	1
Enforcement	1	1	1	0	0	2
Total importance factor	4	4	4	2	3	3

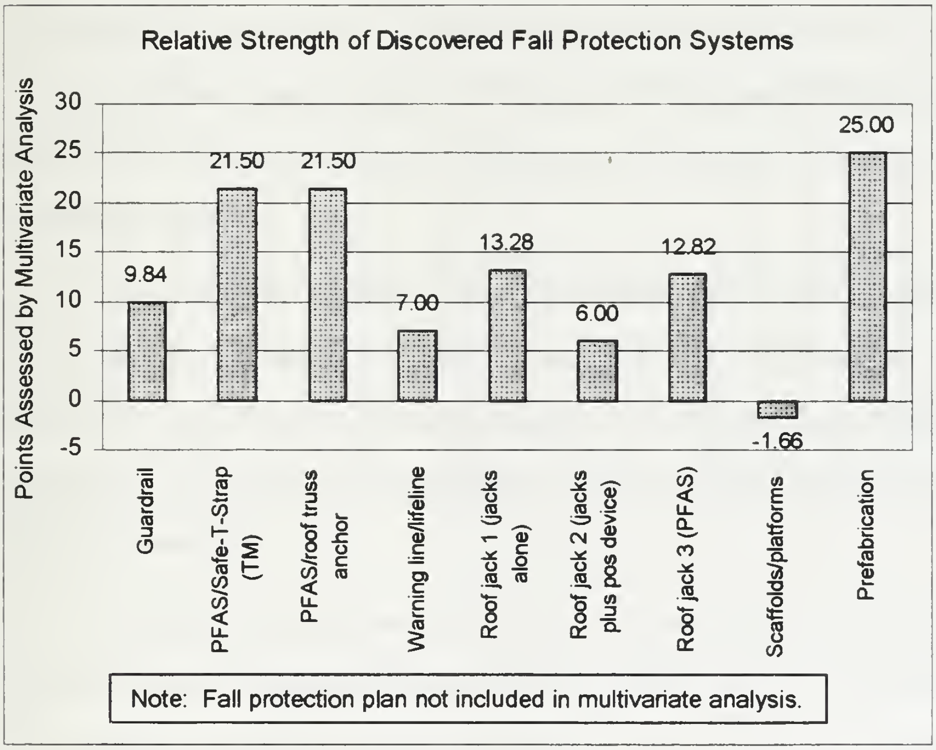

Figure 6.5: Results of multivariate analysis of discovered systems

factors show that feasibility, simplicity, and economy are the most important factors in selecting a fall protection system, followed by passivity and protection, with flexibility being the least important.

For the multivariate analysis, each of the system's criterion scores was multiplied by its importance factor to produce a weighted criterion score. These weighted criterion scores were then summed for each system to produce an overall system score in the range of -40 to +40. The results are given in Figure 6.5 (preceding page). The fall protection plan was not evaluated with the other systems, as its degree of protection and degree of passivity vary according to the fall protection methods it employs.

The results show that prefabrication best meets the various parties' criteria. If modified and adapted for the entire roof system assembly, prefabrication could prove to be an effective method of fall prevention, through the elimination of fall hazards. While only slightly feasible, prefabrication is highly economical, highly protective, highly passive, moderately simple, and moderately flexible.

The next most promising systems are the PFAS variants. PFAS are highly feasible and protective, and moderately simple, economical, and flexible. Still, these variants only achieve slightly more than half of the total points available. Their primary disadvantage is their low degree of passivity. These systems require frequent worker involvement, which also detracts from worker productivity.

The roof jack system also seems to be a promising system of fall protection under conditions 1 and 3, receiving almost a third of the positive points. Under condition 3, this system is very similar to the PFAS variants, except that it is not as flexible nor as economical. Under condition 1, the roof jack system only has one disadvantage, and that is the degree of worker protection. This system does not offer workers the same degree of protection as they are afforded under Subpart M. However, it is highly feasible, somewhat economical, quite passive, and moderately flexible.

The guardrail system, warning line/lifeline system, and roof jack system under condition 2 (roof jacks plus positioning device) also received positive scores, but they were all relatively low scores. Finally, the use of scaffolds and work platforms, which seemed so promising prior to analysis, received an overall negative score.

Unfortunately, none of the systems discovered during this investigation were able to meet all the criteria. Perhaps further investigation is warranted. Nevertheless, prefabrication, PFAS variants, and the roof jack system under low-sloped conditions appear to have enough support from the fall protection community to be self-sustaining, if a "jump start" is given. Methods of initiating this "jump start" will be examined in Chapter 7.

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Chapter 7: Conclusions and Recommendations

7.1 Conclusions

In addition to the detailed findings presented in sections 3.4, 4.4, and 5.4, the following conclusions can be drawn from the research:

(1) Falls continue to be a serious issue that concerns contractors, labor, and enforcement. Therefore, protection of residential construction workers from fall hazards is vital. The workers themselves feel that positive protection is needed while working on all roofs having slopes exceeding 4:12.

(2) The current state of compliance is poor, as observed during job site inspections. Compliance increases with owner oversight, such the single homeowner sector has the worst state of compliance, and the public sector has the best.

(3) Factors of non-compliance include:

- The degree of competition found in the residential construction industry, as characterized by attempts to keep costs to a minimum and productivity at a maximum, sometimes at the expense of safety.
- Worker behavior, caused primarily by concerns to increase productivity and comfort. Workers will comply with regulations if they feel a personal concern for their safety that outweighs their concerns for speed and comfort.
- Design difficulties, such as vaulted ceilings, which may result in greater hazards to protect employees than to allow them to work unprotected under a fall protection plan.

- Conventional construction methods, which call for techniques such as walking the top plate during truss installation.
- Lack of knowledge and training, for both the contractor and the worker.

(4) The new fall protection regulations under Subpart M are cumbersome and difficult for workers and contractors alike to understand and to implement, especially for residential roof construction. The resulting confusion has led contractors and workers to believe that they are in compliance when in fact the inspections show otherwise. The fall protection plan is particularly misunderstood, as evidenced by the poor analysis accomplished and protection provided by two of the three plans shown in Appendix C.

(5) To improve worker protection, the following courses of action have support from the residential construction community:

- Developing innovative methods of protection.
- Increasing worker and contractor training.
- Subsidizing costs of fall protection systems.
- Increasing cooperation with HIOSH.
- Changing the safety culture in residential construction.
- Increasing regulatory oversight, especially in the single homeowner sector.

(6) While current fall protection regulations stress that employers must protect their workers from falls, they do not emphasize the hierarchy of fall protection: Eliminate the hazard, prevent the fall, arrest the fall, and finally, provide warning. If followed, this hierarchy can result in the development of alternative methods of construction,

such as prefabrication, which may prove both feasible to the contractor and protective of the workers.

(7) For fall protection systems to be implemented on residential construction projects, they must be feasible, simple, economical, passive, protective, and flexible. No single available system meets every criterion. Those coming closest are prefabrication, PFAS, and the roof jack system.

7.2 Recommendations

Based on the conclusions presented above, the following recommendations are proposed to improve the protection of residential roof construction workers from falls:

(1) Reduce the complexity of the regulations. Currently, residential roofers must comply with the requirements of §1926.501(b)(10) *Roofing work on low-slope roofs*, §1926.501(b)(11) *Steep roofs*, or §1926.501(b)(13) *Residential construction*. Each of these subparagraphs outlines different requirements, making it difficult for the residential roofing to know which one applies. Additionally, the fall protection plan regulation, §1926.501(k), currently does not require a thorough hazard analysis from contractors who use it, as shown by the poor examples given in Appendix C. Recommendations for changes to the specifications are addressed in section 7.2.1.

(2) Provide incentives for compliance. Through increased cooperation, reduced oversight, fall protection subsidies, and so on, the State of Hawaii can increase compliance without increasing enforcement. These incentives are discussed in section 7.2.2.

(3) Increase the oversight, if not the enforcement, of the single homeowner sector, by requiring special permits for renovations and home repair. Increased oversight is discussed in section 7.2.3.

(4) Develop a cooperative education program for contractors and workers alike. Provide training in hazard analysis and the hierarchy of fall protection, from elimination to prevention to arrest to warning. Cooperative education is discussed in section 7.2.4.

(5) Hawaii's residential construction safety culture must be improved at all levels from the worker to the developer to the individual homeowner. Ideas for improving the safety culture are given in section 7.2.5.

(6) Finally, innovative methods of protecting the workers must be developed. As discussed above, none of the methods found during the investigation meets all the criteria established by contractors, workers, and enforcement. An independent hazard analysis should be conducted for each phase of construction to determine appropriate methods of fall prevention and/or protection. This is further discussed in section 8.3.

7.2.1 Specifications

The complexity of the regulations needs to be reduced. One way to improve the regulations is to reduce the amount of possibilities open to the residential roofer. In order to do this, the current clause regarding residential construction, §1926.501(b)(13), should be changed. The only areas in which HIOSH feels the residential construction worker may not be able to comply with regulations is in framing construction. Therefore, only residential framing contractors should be allowed to utilize §1926.501(b)(13).

Residential construction is never defined in Subpart M. OSHA Instruction STD 3.1 defines residential construction as applying to "structures where the working environment, and the construction materials, methods, and procedures employed are essentially the same as those used for a typical house (single-family dwelling) and townhouse construction." This definition is vague and offers all residential construction work to proceed using the fall protection plan instead of conventional protection. The work to which this clause was originally supposed to apply is

lightweight framing construction, not the entire scope of residential construction. Therefore, the clause should be rephrased so that it only applies to framing phases of operation.

Additionally, the current regulations do not provide for the adequate protection of workers under a fall protection plan. As evidenced by the fall protection plans provided in Appendix C, a plan can be effective or ineffective in outlining the fall hazards faced by employees, and in conducting an adequate analysis so that these hazards can be prevented or employees can be protected. Currently, most plans do not address the fall hazards and provide for a detailed hazard analysis. Contractors assume that the hazards cannot be eliminated, and therefore they conclude why conventional fall protection measures are infeasible. In most instances, however, the fall hazards could be eliminated or at least reduced, as called for by the hierarchy of fall protection. When using the fall protection plan, the contractor should go through this hierarchy, first addressing why the hazards cannot be eliminated before moving on to protection.

To eliminate the confusion in the regulations and to increase the degree of protection afforded to workers under the fall protection plan, the following changes should be made (changes are highlighted):

§1926.500(b) *Definitions.* [Add the following definition:]

Lightweight framing construction means the framing of a structure using lightweight wood or light gauge steel members, as found in the typical single-family dwelling. It includes exterior and interior wall panel erection, joist and truss installation, and floor and roof sheathing; following sheathing, the framing phase is complete.

§1926.501(b)(13) *Lightweight framing construction.* Each employee engaged in lightweight framing construction activities 6 feet (1.8 m) or more above lower levels shall be protected by guardrail systems, safety net system, or personal fall arrest system unless another provision in paragraph (b) of this section provides for an alternative fall protection measure. Exception: When the employer can demonstrate that it is infeasible or creates a greater hazard to use these systems or to modify construction such that the hazard is eliminated, the employer shall develop and implement a fall protection plan which meets the requirements of paragraph (k) of §1926.502.

Note: There is a presumption that it is feasible and will not create a greater hazard to implement at least one of the above-listed fall protection systems, or to eliminate the fall hazard altogether. Accordingly, the employer has the burden of

establishing that it is appropriate to implement a fall protection plan which complies with §1926.502(k) for a particular workplace situation, in lieu of implementing any of those systems.

§1926.502(k) *Fall protection plan.* This option is available only to employees engaged in leading edge work, precast concrete erection work, or lightweight framing construction work (See §1926.501(b)(2), (b)(12), and (b)(13)) who can demonstrate that it is infeasible or it creates a greater hazard to either eliminate the fall hazard or to use conventional fall protection equipment. The fall protection plan must conform to the following provisions:

(1) The fall protection plan shall be prepared by a qualified person and developed specifically for the site where the leading edge work, precast concrete erection work, or lightweight framing construction work is being performed and the plan must be maintained up to date. . . .

(5) The fall protection plan shall include a written discussion and analysis of fall hazards. The plan shall outline steps taken to eliminate or reduce the fall hazards for workers, to include the use of alternative construction methods. For example, the employer shall discuss the extent to which scaffolds, ladders, or vehicle mounted work platforms can be used to provide a safer working surface and thereby reduce the hazard of falling, or the extent to which prefabrication can be used to eliminate the fall hazard. The fall protection plan shall document the reasons why any such alternative construction methods are infeasible or why their use would create a greater hazard. [Replaces current subparagraph (6).]

(6) The fall protection plan shall document the reasons why the use of conventional fall protection systems (guardrail systems, personal fall arrest systems, or safety net systems) are infeasible or why their use would create a greater hazard.

7.2.2 Incentives for Compliance

In order to improve worker protection, the contractors must see that the benefits of complying with the regulations exceed the costs. By providing incentives for compliance, the State of Hawaii can either increase the benefits or reduce the costs.

Increasing the benefits of compliance could include possible liberties, such as reducing compliance inspections, if and only if the contractor demonstrates a commitment to working safely. OSHA has two such programs in effect: the Voluntary Protection Program (VPP) and the Safety and Health Achievement Program (SHARP). According to OSHA's Compliance Office, SHARP "provides incentives and support to smaller, high-hazard employers to develop, implement and continuously improve effective safety and health programs at their worksite(s)."

Employers desiring to be in the program first request a compliance assist visit. If they meet program requirements, they can then be exempted from routine OSHA inspections for one year (OSHA, 1997).

VPP is similar, but is applicable to all employers. For an employer to become a part of VPP, the company must first demonstrate a commitment to safety through a comprehensive safety program and a thorough application process. After OSHA verifies that the employer meets the VPP criteria, they will "publicly recognize the site's exemplary program, and remove the site from routine scheduled inspection lists." The site is reassessed periodically (every 1-3 years) to confirm that the employer continues to meet VPP criteria (OSHA, 1997). Programs like VPP and SHARP can provide some of the incentives needed by Hawaii's residential contractors. However, the cost of implementing a comprehensive safety program from scratch can be intimidating, and may not be seen as worthwhile unless more incentives are included.

Another incentive could be to allow safe contractors a significant discount on their workers' compensation rates. The State of Hawaii could provide employers in programs like VPP or SHARP with discounted rates. Since workers' compensation rates are estimated to be up to 25% of the cost of labor (Cordes, 1996), a significant discount could cause a large impact on the employer's bottom-line.

The other method to providing incentives is through lowering the costs of fall protection systems. One method of lowering the costs is by establishing a safety tax credit. Such a credit would allow contractors to deduct a percentage of the costs of safety equipment from their corporate tax bill (Dobslaw, 1997). This tax credit could be offered to individuals as well, for the benefit of the single homeowner sector that is dominated by sole proprietorships.

Alternatively, the State of Hawaii could directly subsidize the cost of fall protection equipment. This could be accomplished by raising permitting fees, and applying the additional proceeds to a fund set aside for improving residential safety.

7.2.3 *Increased Oversight*

As mentioned above, oversight can be increased without increasing enforcement. Oversight is merely external supervision. It is another set of eyes which can assist the contractor in protecting his or her workers. One method of increasing oversight is by requiring permitting of residential renovation and repair. The city of Denver currently requires permits for reroofing (Chong and Subiono, 1997), so it is quite feasible to implement this requirement. The additional funds brought in by permitting could be used for improving residential construction safety, through direct subsidies of equipment, as described above, or through education, as described below.

Oversight can also come from the risk managers. If workers' compensation rates are the key to the contractors' pocketbooks, then the risk managers hold the key (Norris, 1997). Increased involvement from the risk managers can result in improved safety programs, including fall protection programs.

Since worker compliance increases with the degree of owner oversight, another method of increasing oversight is by educating individual homeowners on their responsibilities to provide a safe workplace for contractors' employees. The elements required for this education process are discussed below.

Yet another method of increasing oversight is by changing the licensing requirements for contractors. Currently, to become a licensed contractor, an individual has only to demonstrate four years of supervisory experience, obtain three referrals from existing contractors, and have $25,000 in cash assets. The individual need not demonstrate his or her actual knowledge of safe and responsible construction methods. If testing and/or educational requirements were added to the licensing requirements, this could impact the level of knowledge, especially for the smaller contractors (Lyons, 1997). Again, education is further discussed below.

Of course, increased oversight can also be accomplished through increased enforcement by HIOSH and OSHA. Currently, HIOSH fines for failing to provide fall protection are lower than

the cost of fall protection equipment. Therefore, the contractor obviously feels compelled not to comply. The costs of compliance exceed the costs of noncompliance. If the climate is to change, fines must be increased, so that the cost of noncompliance is higher than the cost of compliance.

7.2.4 Cooperative Education

Protecting workers from fall hazards in residential roof construction is an issue that can only be resolved when all the affected parties work together. One method of bringing them together is through education. By educating the workers, supervisors, architects, contractors, risk managers, and homeowners, all parties can better understand the issues involved.

Both labor and contractors felt that HIOSH could improve its cooperative efforts with the construction community. The current attitude is "us against them," which is not conducive to protection of the workers. Additionally, there appears to be a lack of knowledge in both the residential construction worker and the residential contractor. To address this void and to resolve the "us against them" dilemma, HIOSH should develop a cooperative education program focused particularly on fall protection. This program could work like the VPP and SHARP programs mentioned above, only include training of the contractors and their workers in fall prevention and protection. Prior to the training, HIOSH could help the contractor establish a fall protection program that would address site-specific fall hazards, and then provide the contractor with a certification of safe work practices, allowing reduced regulatory oversight or reduced workers compensation rates as described above. Such a program takes the incentive programs of VPP and SHARP one step beyond. Of course, this would also increase HIOSH's budget requirements. These additional costs could be provided by increased permitting fees or increased licensing fees.

The individual homeowners must also be educated in their responsibilities to provide a safe workplace for contractor's employees. Educating the public can be accomplished through the media, through neighborhood associations and meetings, and by direct mailing.

Neighborhood associations typically establish and periodically publish the rules regarding renovations and repairs to homes, so they may be the most effective agents to educate the individual homeowner.

When a homeowner is accomplishing extensive renovation or remodeling, he or she typically hires an architect. The architect may therefore also be a catalyst for change. Currently, there is an ongoing debate as to the role an architect plays in designing for safety, but the results of this investigation show that safety can be influenced by the design of the home. Architects themselves must therefore be educated in the hazards faced by the workers who build the homes that they have designed. Architects can be educated through the American Institute of Architects (AIA), their professional organization.

7.2.5 Improving the Safety Culture

The final recommendation to improve worker protection is to improve the safety culture. Some of the most promising systems analyzed in Chapter 6 were PFAS variants. Unfortunately, these systems may stand the least chance of being effectively used, because the workers find them uncomfortable and impeding. The only way these systems can be effectively implemented is by changing the culture of Hawaii's residential construction industry.

Workers in the residential construction industry are primarily motivated to comply with fall protection regulations when and if they feel a personal concern for safety. This is the key to motivating safe behavior. Beginning with apprentice training at the union hall, and ending with supervisory reinforcement from the foreman, the worker needs to hear about the dangers of falling during residential roof construction.

Just hearing about it isn't enough. If the worker is told about the hazards, yet then is shown by example that fall hazards are a condition of employment, he or she will become accustomed to the fall hazard, and not question its existence. Unsafe, conventional construction methods like "walking the top plate" must be eliminated. A strong message must be sent from

HIOSH to contractors who violate the standards of Subpart M. There is always a safe alternative. The workers could utilize ladders or sawhorse scaffolds if nothing else. If the message is sent out, and strict enforcement is implemented in this regard, the contractors will learn that the use of alternative, safe work practices are not considered to be infeasible.

The message must be clear. It must be adamantly applied. Fines should be expensive--more expensive than the costs of implementing safe work methods. Only then will contractors see that the costs of compliance do not exceed the costs of noncompliance.

Changing a culture is a slow process. One proven method of changing the safety culture is by targeting children. When seatbelt use was low in the 1960s and 1970s, it was because individual users felt them to be "uncomfortable" and to "get in the way." The United States government initiated a series of creative advertisements involving the "crash test dummies." Such advertisements were aimed at youth, and they were effective. Twenty-five years later, the vast majority of individuals use seatbelts voluntarily.

Children are influenced most by television. Dramatic commercials involving falls--using creative agents like the crash test dummies--can change the way children view the hazards of their own and others' roofs. When they have grown, and are in the workforce, they will remember the catchy phrase, like, "Don't be a dummy. Buckle up." They will opt for protection. Also, the children themselves can then serve as an agent for change, imploring their construction worker parents to buckle up too.

A mass media blitz may not be as effective as actually targeting the construction workforce. One of the construction managers suggested that coloring books be published highlighting various aspects of construction safety. These books could be distributed to contractors, who would give them to their employees, who in turn would give them to their children. Hopefully, this could help both the workers and their families to understand the hazards they face daily. By explaining these hazards to their children, the workers would be forced to acknowledge their own need to protect themselves from the hazards, and therefore motivate

themselves towards safe behavior. Such a campaign could be conducted on a Hawaii-wide basis for less than $10,000 (Norris, 1997).

7.3 Need for Change

In summary, five recommendations have been offered for improving the protection of residential roof construction workers. Each of the five can be effective, and offer some improvements. The most dramatic improvement would result by implementing all of the five together, but that may not be possible.

Regardless, something must be done to initiate voluntary compliance. "Business as usual" will not result in fewer fall accidents. Confusion reigns in Hawaii's residential construction industry regarding the application of fall protection standards, and often, this results in the worker failing to be protected from fall hazards. Sadly, falls remain the number one killer in construction. Hawaii's last fall fatality from a residential construction accident was in January 1996. Statistically speaking, Hawaii should not see another fatality for some time. But are we willing to risk the life of one worker in this debate? Now is the time for action. Only through a concerted effort of the entire community can Hawaii's workers be protected from the fall hazards they face daily.

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Chapter 8: Summary

8.1 Fulfillment of Objectives

The objectives of this investigation were first presented in Chapter 1. They are:

(1) Assess the current status of compliance with Hawaii state fall protection requirements.

(2) Analyze the sources of non-compliance with fall protection regulations in residential roof construction.

(3) Identify the fall protection requirements of the various parties involved in residential construction safety.

(4) Examine existing methods of fall protection for residential roof construction for their ability to meet those requirements.

(5) Incorporate the results of the investigation into specifications and other actions for HIOSH implementation.

These objectives have each, in turn, been fulfilled as follows.

8.1.1 Assessment of the State of Compliance

The state of compliance was assessed through interviews of construction managers, union officials, and enforcement officials; worker surveys; job site inspections; and a review of case histories. Together, these methods were used to assess the current state of compliance with fall protection regulations in the residential construction industry. The state of compliance is poor, as evidenced primarily by the job site inspections. However, construction managers and workers do not feel that it is as much of a problem as was shown during inspections. This indicates a potential lack of knowledge regarding the regulations.

8.1.2 Analysis of Non-Compliance Factors

Factors leading to non-compliance were obtained through interviews and surveys. The results showed that non-compliance was primarily a result of the competitiveness of Hawaii's residential construction industry, although worker behavior, design problems, construction method problems, and a lack of knowledge were also found to be contributing factors.

8.1.3 Identification of Requirements

The residential construction industry's criteria for fall protection systems were assessed from the interviews, surveys, and perusal of the current regulations. For a fall protection system to be implemented voluntarily in residential roof construction, it must be feasible, simple, economical, passive, protective, and flexible. The residential construction industry's criteria for fall protection systems were assessed from the interviews, surveys, and perusal of the current regulations. For a fall protection system to be implemented voluntarily in residential roof construction, it must be feasible, simple, economical, passive, protective, and flexible.

8.1.4 Analysis of Fall Protection Methods

Many fall protection methods were discovered during the job site inspections. Eight of the most promising methods were analyzed for their abilities to meet the six criteria. Unfortunately, none of the eight were able to meet all six criteria. However, the PFAS variants described in section 6.3.2, and prefabrication methods described in section 6.3.7, came closest to fulfilling all criteria. Thus, no system discovered will be able to be implemented without government intervention/assistance.

8.1.5 Development of Specifications and Other Actions

Chapter 7 thus presented several courses of action that could be used to provide the intervention and/or assistance required. One such method involved changing the current specifications. Recommendations were given in section 7.2.1 for changing the specifications to

Job Hazard Analysis Form

JOB TITLE: ______________________________ DATE OF ANALYSIS: _____________

JOB LOCATION: ____

STEP	HAZARD	NEW PROCEDURE OR PROTECTION

Figure 8.1: Job hazard analysis form (Source: OSHA, 1984)

make them clearer and more protective. Various incentives designed to initiate voluntary compliance were given in section 7.2.2. Methods for increasing oversight without increasing enforcement were discussed in section 7.2.3. Section 7.2.4 presented methods for educating the various parties in their responsibilities to ensure the safety and protection of residential construction workers. Finally, section 7.2.5 provided ideas for how to improve the safety culture of Hawaii's residential construction workers.

8.2 Recommendations for Further Study

Since none of the alternative methods discovered during the course of this investigation meet all the criteria, further study should be undertaken to analyze the specific fall hazards peculiar to residential roof construction, and to develop innovative methods of protecting the workers from those fall hazards. Such a study would involve a separate job safety analysis, as shown in Figure 8.1 (preceding page), for each task involved in residential roof construction. Such an analysis would be necessary to develop innovative methods of protecting workers during residential roof construction. The analysis could result in a decision tree for situation-specific appropriate fall protection, based on the task, slope, and other important factors.

The issues behind unsafe worker behavior could also be studied more thoroughly. As briefly discussed in Chapter 2, NIOSH conducted such a study in 1975. It appears that the culture may have changed since then. The workers in the NIOSH study were most often motivated to work safely because of their supervisor's actions and attitudes. This investigation found that workers were primarily motivated to comply with regulations when they were personally concerned about their own safety, indicating that their values--and thus the culture--may have changed.

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Appendix A: Fall Protection Systems

Contents

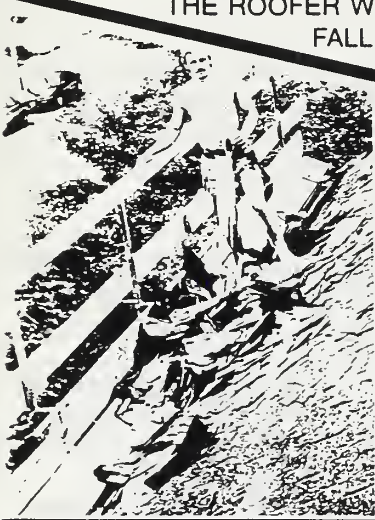
Exhibit A.1: PR20 Eave Catchguard System

THE FINAL ANSWER FOR SLOPED ROOFING
AN EDGE PROTECTION SYSTEM THAT INCREASES PRODUCTION

PR 20 EAVE CATCHGUARD

<u>**PR 20**</u>

EAVE CATCHGUARD
THE ULTIMATE
PLATFORM GUARDRAIL
SYSTEM THAT SETS UP
IN MINUTES AND PROVIDES
THE ROOFER WITH MAXIMUM
FALL PROTECTION



<u>**PR 20**</u>

WAS TESTED AND ENGINEERED TO WITHSTAND FALL IMPACTS WHILE PROVIDING A CONTINUOUS WORKING PLATFORM THAT CATCHES FALLING DEBRIS, MATERIALS & TOOLS. **PR 20** DOESN'T INTERFERE WITH THE ROOFING PROCESS, DISMANTLES QUICK AND EASY, TAKES UP LITTLE STORAGE SPACE.

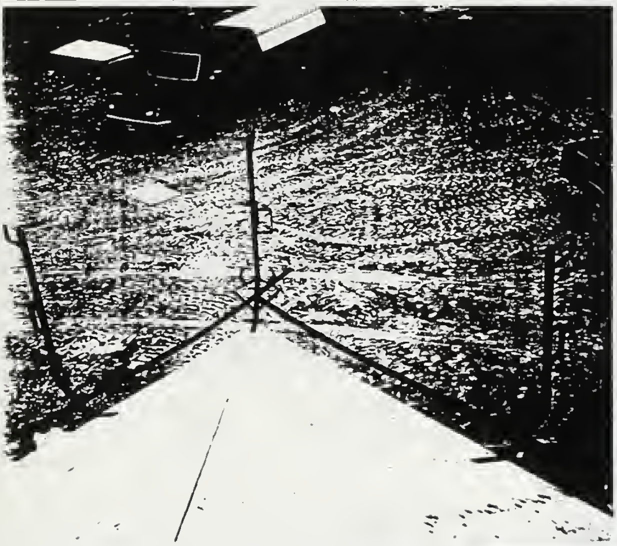
PR 20 EAVE CATCHGUARD HAS BEEN TESTED AT WARNOCK HERSEY LABORATORY IN ACCORDANCE WITH M.O.L., O.S.H. A. & W.C.B. FALL ARREST. **PR 20** IS INEXPENSIVE, LIGHTWEIGHT, RUGGED & EASY TO INSTALL.

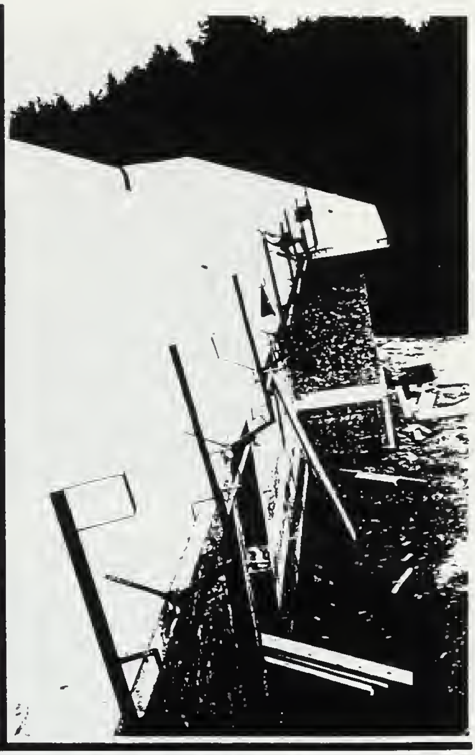
* PATENT PENDING

Exhibit A.1: PR20 Eave Catchguard System

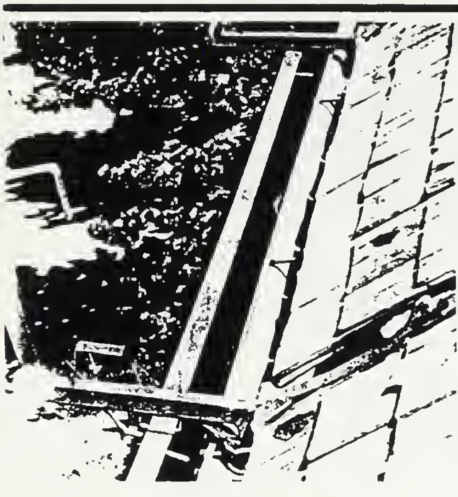
PR 20 EAVE CATCHGUARD
CAN BE INSTALLED EASILY BY JUST ONE PERSON IN MINUTES.

PR 20 WILL FIT AROUND CORNERS





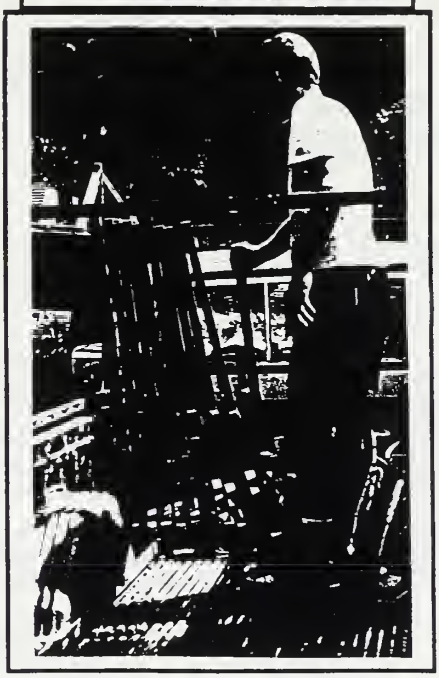
PR 20 DOES NOT INTERFERE WITH EAVESTROUGHS AND WORKS PERFECT FOR REROOFING.



ONCE THE PLANKS & RAILS ARE INSTALLED
PR 20 EAVE CATCHGUARD
PROVIDES THE WORKER WITH A PRACTICAL BARRICADE AND BASE SUPPORT.

Exhibit A.1: PR20 Eave Catchguard System

PR 20 EAVE CATCHGUARD RAFTER BRACKET can be easily shingled over using asphalt shingles, cedar shakes or almost any other type of roofing material. Then when the job is complete simply pull out the coupling pin, insert bracket nockout, tap up and the rafter bracket will slide off the nails.



PR 20 is light weight (less than 9 lbs) and can be easily stored in the corner of a pick-up or trunk of a car ready for the next job.

PR 20 EAVE CATCHGUARD was designed by a roofer with the help of a technical fitter to provide ease and practical set up time combined with maximum strength for use in the roofing industry.

For more information on how the **PR 20** can benefit you on your next job or a distributor near you call:

ROOFMASTER®
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Manufacturers & Distributors of Roofing Equipment, Tools & Accessories
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1-800-372-6409	1-213-261-5122	1-800-421-6174
CA except 213 & 818 areas	FAX 1-213-261-8799	Nationwide except CA.

Manufactured By:
Protective Roofing Products Ltd.

Exhibit A.2: Trus-T Roof Anchor for PFAS

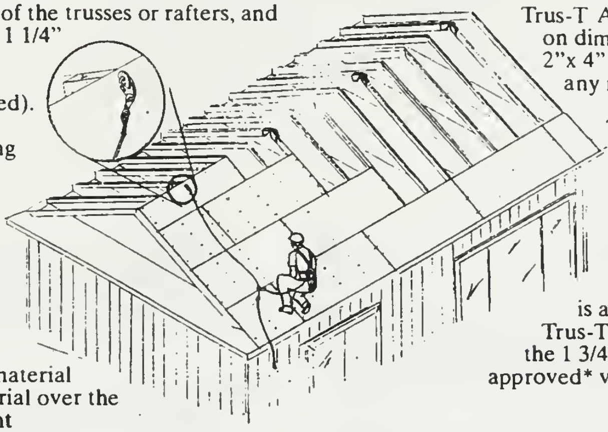
Trus-T

FALL PROTECTION ANCHOR POINTS

Installation

All Trus-T Anchor Systems must be installed a maximum of 8' O.C. at the top of trusses or rafters.

Trus-T Anchor is made to be bent to conform to the pitch/angle of the trusses or rafters, and then secured with 1 1/4" joist nails (Note: All pre-drilled holes are to be used).



To install sheathing over the Trus-T Anchor upright:

1) Determine proper placement of sheathing
2) Make a 4" saw kerf through the material
3) Lay the material over the Trus-T upright
4) Re-connect the locking carabiner and safety line.

Purpose

To provide a safe and economical anchor point for framers, carpenters, and roofers for use during initial construction of roof rafters, setting of pre-manufactured trusses, and installing sheathing/roof covering materials, while meeting or exceeding State and Federal OSHA compliance standards.

Capacity: 1 man per anchor.

Description/Specifications

Trus-T Anchor provides safe "tie-off" anchor points for workers and complies with State and Federal OSHA regulations, as well as meeting ANSI Standards.

Trus-T Anchor can be used on dimensional lumber 2"x 4" through 2" x 12", any roof pitch.

Trus-T Anchors are pre-drilled for attachment with 1 1/4" joist nails (provided).

An approved locking carabiner is attached to the Trus-T Anchor through the 1 3/4" upright. Then an approved* vertical lifeline with:

1) an in-line deceleration device
2) a self-retracting lifeline, shall be installed and attached to a "D" ring on the back of the user**/worker's approved full body harness.

Notes:

* Approved: For the purpose of this brochure shall mean, any component used with the Trus-T Anchor System that is made or supplied by another manufacturer. Said manufacturer shall warrant that such components are tested and comply accordingly with U.S. Department of Labor, and Federal OSHA Standards.

** User: for the purpose of this brochure shall mean anyone who purchases, employs, trains, or is responsible for training, or attaches to the Trus-T Anchor.

Manufactured By:

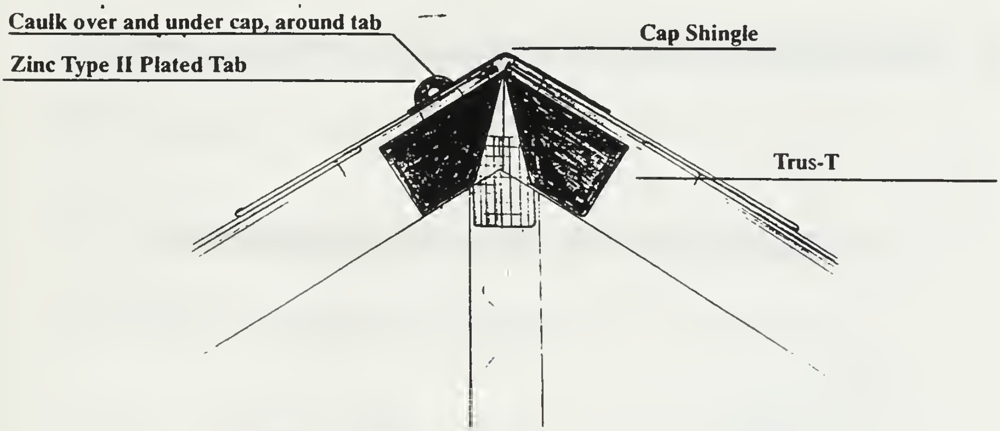
Guardian Metal Products, Inc.

"At the TOP OF THE LINE in safety!"

Exhibit A.2: Trus-T Roof Anchor for PFAS

PERMANENT

FALL PROTECTION ANCHOR POINTS



e Trus-T is designed to be installed before ..ie trusses are raised onto the walls. Place a Trus-T on every fourth truss while the trusses are on the ground.

When the trusses are in place at 2' o.c.. The anchors will be properly spaced. Now all workmen from the framer through the roofer can be "in compliance".

The tab can be either bent over to complete the roof or left exposed (see detail) for use by the building owner for maintenance and repairs.

Can be used while cleaning gutters, valleys, skylights or during snow removal and wind repair.

You will remember us when the Christmas lights are being installed.

Testing

Objective:
Test Trus-T Anchor Point to prove compliance with current OSHA Standards requirements at 5,400 lb. maximum loading (ref. part 1926).

Procedure:
The device was attached securely to the apex of a triangular truss with 16 1 1/4" truss nails. An approved (5,400 lb. rated) carabiner was then provided to interface between the Trus-T anchor and the 3/8 inch galvanized, 14,400 lb. tensile strength wire rope which was then attached to a 5,000 plus lb. load cell.

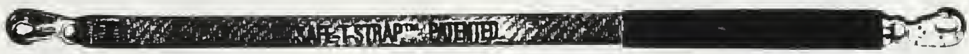
Testing of the Trus-T anchor took place in 1,000 lb. increments to determine if any deformation was evident in the device. None was noted. Final loading of the device took place at 5,400 lbs. with minimal deformation visible.

Photographs were taken at each 1,000 lb. stage as well as the attained 5,400 lb. load and are included with this report.

Exhibit A.3: Safe-T-Strap™ for PFAS

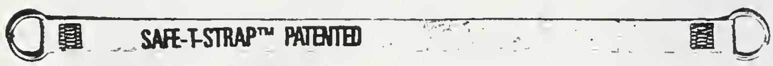
SAFE-T-STRAP PRODUCTS

LIBERTY SAFETY PRODUCTS INC

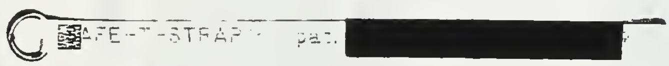


LANYARD F.L.L.-4
• 6000 lb. test certified webbing • 5000 lb. test double locking plated snap hooks • Abrasion protective sleeve reinforcing covering • Certified nylon thread stitch pattern • 4' standard length • 2' to 5' lengths available

LADDER HOOK L.H.L.L.-5
• 6000 lb. test certified webbing • large double locking snap hook on one end suitable for securing to large anchor points • Abrasion protective sleeve • 5' standard length • 2' to 6' lengths available

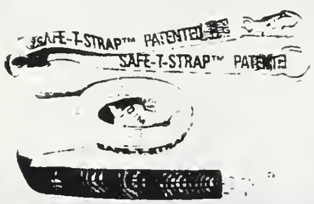


SCAFFOLD STRAP W.T.S.S.-11
• 6000 lb. test certified webbing • 2 - 5000 lb. test plated D ring • Certified nylon thread stitch pattern



HIGH-RISE SAFE-T-STRAP A.H.R.S.-02
• 6000 lb. test certified webbing • 5000 lb. test plated D ring • Certified nylon thread stitch pattern
• Abrasion protective sleeve

RESIDENTIAL SAFE-T-STRAP U.S.L.R.S.-01
• 6000 lb test certified webbing • 5000 lb test plated D ring • Certified nylon thread stitch pattern



TRAVEL RESTRAINT "LIFELINE" T.R.-35
• 6000 lb test certified webbing • 5000 lb. test plated adjustable cam buckle • 5000 lb test double locking snap hooks • Abrasion protective sleeve • 35' standard length • Custom lengths also available

Exhibit A.3: Safe-T-Strap™ for PFAS

SAFE-T-STRAP IN ACTION

LIBERTY
SAFETY PRODUCTS INC.

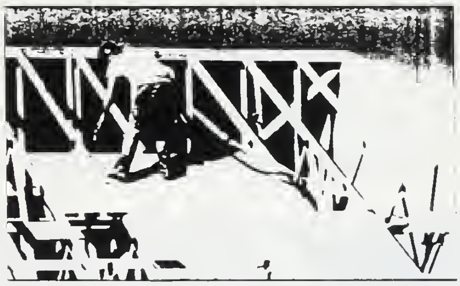
Excellent for brick laying or precast work at building perimeters.

SAFE-T-STRAP is the safest system for stripping and erecting form work, reshores, guard rails, etc.

Easily accessible for all types of exterior work. ie: bricklaying, cladding, glazing, etc.

The only system for ladder work such as installation of soffit, fascia, eavestroughing, caulking, etc.

Ideal for many situations such as fly form work & receiving material



Our system provides complete fall arrest for all carpenters and roofers

Exhibit A.4: 2-man Roof Anchor System for PFAS

2 Man Roof Anchor System

With Nail In Option

APPLICATION

SINCO's reusable Roof Anchor System offers a quick and safe way of providing fall protection for personnel working on a roof. Simply drill a 1-1/2" hole adjacent to a rafter or truss, feed the foot of the anchor through the hole, capturing the rafter or truss, tighten the wing nut, and your anchor point is ready-to-use.

The system allows for use with a lanyard, rope grab or a retracting lifeline. Multiple units can be installed to construct a horizontal lifeline. **Two workers may share a single anchor.**

The accompanying fall protection components provide "user friendly" features that facilitate use and complete this engineered fall protection system.

(turn over for more information)

800-243-6753

Exhibit A.4: 2-man Roof Anchor System for PFAS

SINCO ROOF ANCHOR SYSTEM

FEATURES

- Engineered system meets fall arrest requirements of OSHA 1926.500, Sub Part M.
- Easy to install and remove.
- Rope Grab provides "user-friendly" convenience and operation.
- Sur-Lock Snap Hooks provide better protection without the inconvenience of conventional Snap Hooks.
- Reduces potential liability posed by permanently installed roof anchors.
- System is equipped with all necessary components that have been matched and tested to ensure maximum safety and ease of operation.
- Will help control workers' compensation costs and OSHA citations.
- System allows for multiple attachment methods and layouts.
- NEW! Unit can be anchored with nails as an option.
- NEW! Two workers can share a single anchor when anchored with the J-bolt.

SINCO DISTRIBUTOR NEAREST YOU

BOC GASES
GASPRO
2305 KAMEHAMEHA HWY, HON HI 96819
PH: (808) 842-2222 • FX: (808) 842-2131
HONOLULU • WAIPAHU • MAUI • KAUAI
HILO • KONA-KAMUELA

Note: SINCO's Roof Anchor System has been designed and tested with SINCO component parts only. U. S. Patent No. #5,143,171
Photos are illustrative only - before using any SINCO product read instructions and warnings supplied with each product.

RAS 4/96 TPC

The SINCO Group, Inc.
One SINCO Place
P.O. Box 361
East Hampton, CT 06424
1 - 800 - 243 - 6753
860 - 267 - 5500 In CT
Fax: 860 - 267 - 5515
Sales Offices Throughout The U.S.

Exhibit A.5: Ridge-Runner System for PFAS

Ridge - Runner System

APPLICATION

SINCO's Ridge-Runner system offers a quick and safe way of providing fall protection for personnel working on a roof or at the "leading edge".

The incorporation of a retractable lifeline affords the user a 50′ radius to perform "hands - free" roof work. Should a free fall occur, the retractable lifeline will restrict the fall distance to inches, greatly reducing the likelihood of any serious injury resulting from an arrested fall.

By incorporating SINCO's recovery lifeline*, the user is afforded the ability to raise or lower a worker after arresting a fall.

**Recovery Lifeline shown in photo*

(turn over for more information)

800-243-6753

Exhibit A.5: Ridge-Runner System for PFAS

SINCO RIDGE-RUNNER SYSTEM

FEATURES

- Engineered system meets fall arrest requirements of OSHA 1926.500, Sub Part M.
- Provides 360° of movement.
- Retractable lifelines are user friendly.
- Retractable lifelines limit free falls to inches and prevent most slips or trips from becoming falls.
- Folds up for easy transport and storage.
- Installs easily on sloped or flat roofs.
- Equipped with all necessary components that have been matched and tested to ensure maximum safety and ease of operation.
- NEW! Optional recovery feature available.

SINCO RIDGE - RUNNER SYSTEM

INCLUDES:

- One Ridge - Runner Base
- One 50′ Retractable Lifeline with Sur-Lock Hook
- Two J-Anchors

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HILO • KONA-KAMUELA

Note: SINCO's Ridge - Runner System has been designed and tested with SINCO component parts only. U. S. Patent No. #5.054.576
Photos are illustrative only - before using any SINCO product read instructions and warnings supplied with each product.

RRS 4/96 TPC

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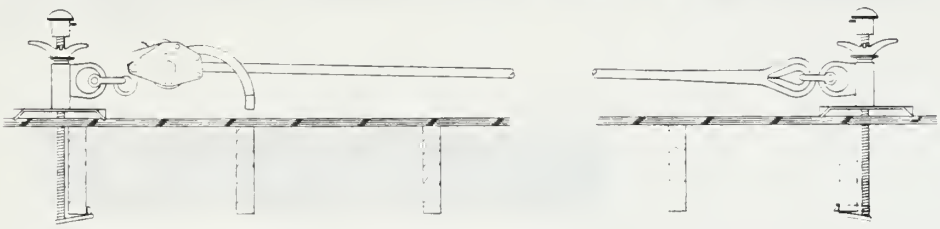
860 - 267 - 5500 In CT
Fax: 860 - 267 - 5515
Sales Offices Throughout The U.S.

Exhibit A.6: 2-man Roof Runner Horizontal Lifeline for PFAS

2 Man Roof Runner© Horizontal Lifeline



APPLICATION

SINCO's reusable Roof Runner© Horizontal Lifeline offers a quick and safe way of providing fall protection for personnel working on a roof. Simply drill 1-1/2" holes adjacent to rafters or trusses, feed the feet of the anchors through the holes, capturing the rafters or trusses, tighten the wing nuts, and your anchor points are ready-to-use.

The system uses a horizontal lifeline with a lanyard, rope grab or a retracting lifeline. **Two workers may share the system.**

The accompanying fall protection components provide *"user friendly"* features that facilitate use and complete this engineered fall protection system.

(turn over for more information)

800-243-6753

Exhibit A.6: 2-man Roof Runner Horizontal Lifeline for PFAS

SINCO ROOF RUNNER© HORIZONTAL LIFELINE

FEATURES

- Engineered system meets fall arrest requirements of OSHA 1926.500, Sub Part M.
- Easy to install and remove.
- Sur-Lock Carabiners provide better protection without the inconvenience of conventional Snap Hooks.
- Reduces potential liability posed by permanently installed roof anchors.
- System is equipped with all necessary components that have been matched and tested to ensure maximum safety and ease of operation.
- Will help control workers' compensation costs and OSHA citations.
- System allows for multiple attachment methods and layouts.
- NEW! Two life lines can share each set of anchors when anchored with the J-bolt.

SINCO DISTRIBUTOR NEAREST YOU

BOC GASES
GASPRO
2305 KAMEHAMEHA HWY, HON HI 96819
PH: (808) 842-2222 • FX: (808) 842-2131
HONOLULU • WAIPAHU • MAUI • KAUAI
HILO • KONA-KAMUELA

Note: SINCO's Roof Runner Horizontal Lifeline has been designed and tested with SINCO component parts only. U. S. Patent Pending
Photos are illustrative only - before using any SINCO product read instructions and warnings supplied with each product.

RRS 4/96 TPC

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Fax: 860 - 267 - 5515
Sales Offices Throughout The U.S.

Exhibit A.7: Rope Grabs for PFAS

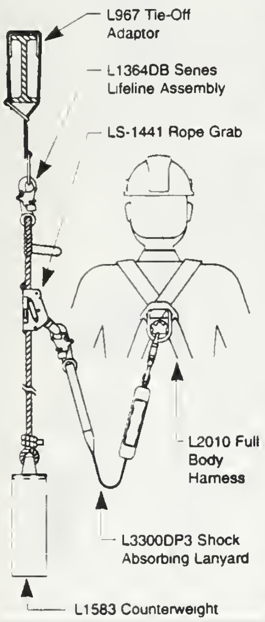
DBI/SALA™ offers a complete line of mobile and static Rope Grabs for both synthetic fiber rope and steel wire cable.

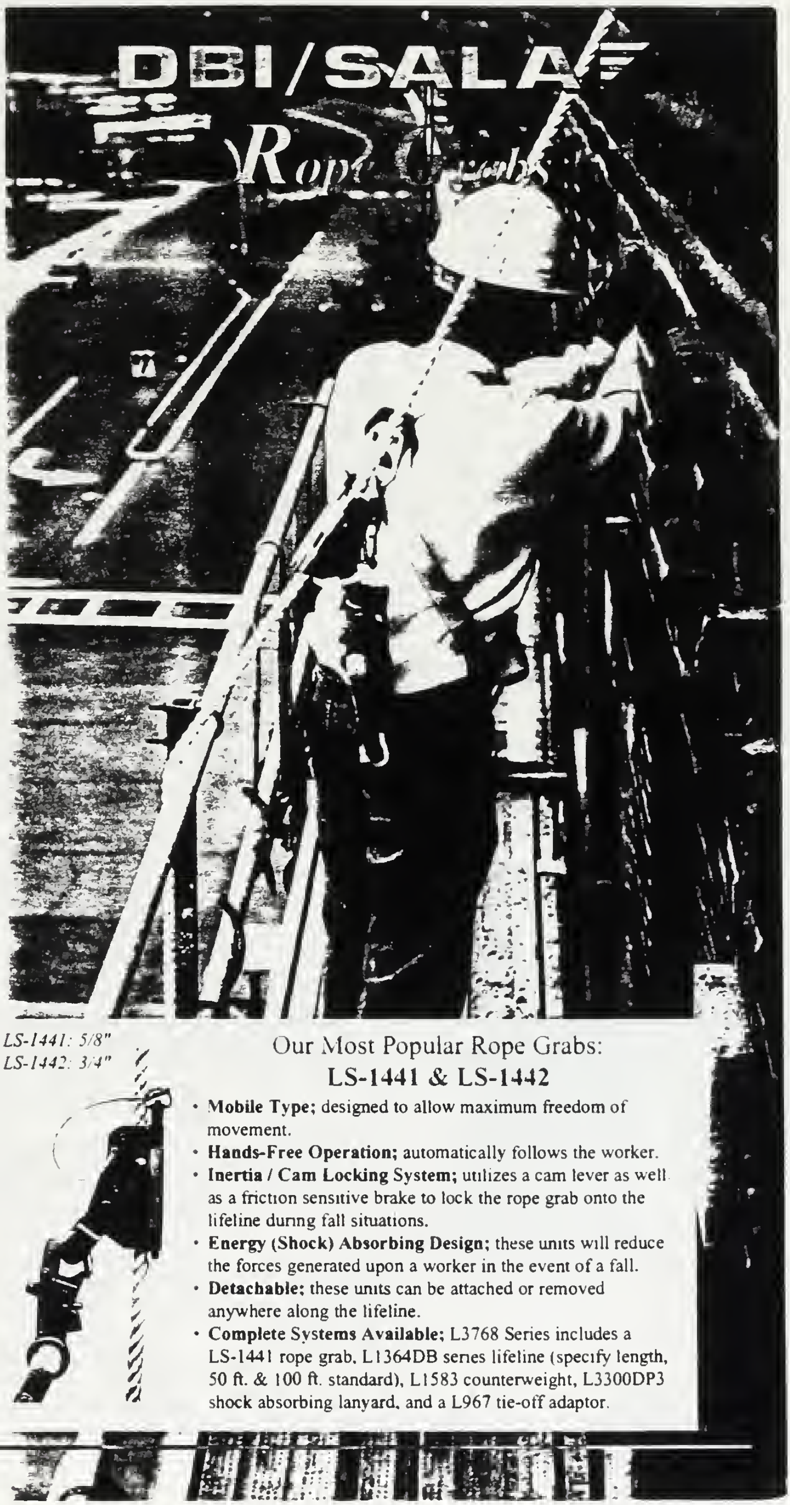
All models are constructed from high grade corrosion resistant materials. In addition, strict quality standards and 100% inspection and testing go into every unit.

We manufacture a complete line of lifelines to be used in conjunction with our rope grabs. They are available in cut lengths or assemblies that include a self locking snap hook attached to one end. We also offer a couple of different styles of counter-weights that can be attached to the end of the lifeline to keep it taut while in use.

DBI/SALA's rope grabs meet or exceed all applicable standards including ANSI A10.14-1991, and OSHA regulations. The LS-1441 and LS-1442 also meet ANSI Z359.1-1992

Typical System
(L3768 Shown)





Our Most Popular Rope Grabs:
LS-1441 & LS-1442

- **Mobile Type;** designed to allow maximum freedom of movement.
- **Hands-Free Operation;** automatically follows the worker.
- **Inertia / Cam Locking System;** utilizes a cam lever as well as a friction sensitive brake to lock the rope grab onto the lifeline during fall situations.
- **Energy (Shock) Absorbing Design;** these units will reduce the forces generated upon a worker in the event of a fall.
- **Detachable;** these units can be attached or removed anywhere along the lifeline.
- **Complete Systems Available;** L3768 Series includes a LS-1441 rope grab, L1364DB series lifeline (specify length, 50 ft. & 100 ft. standard), L1583 counterweight, L3300DP3 shock absorbing lanyard, and a L967 tie-off adaptor.

Exhibit A.7: Rope Grabs for PFAS

DBI/SALA

800-328-6146
(Canada: 800-205-6866)

LS-1441
LS-1442

The LS-1441 and LS-1442 Rope Grabs (Mobile T[illegible]): (see front page for further features/benefits) The LS-1441 is for use on a 5/8" diameter lifeline and the LS-1442 is for use on 3/4" These rope grabs allow for maximum freedom of movement and incorporate an inertia/cam locking system. The rope grab can be attached or removed anywhere along the lifeline. U.S. Patent No 4.657.110. Canada Patent No. 1.241.937. U K. Patent No. GB2.168.102B. LS-1441 NYS Approval No 9194A. LS-1442 NYS Approval No. 9194B

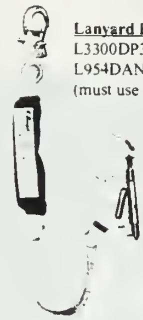
Construction:
Size: 4"x6". 1-3/4 lbs..
Aluminum Stainless Steel

Lifeline Requirements:
L1364DB 5/8" polyester/polypropylene blend. self locking snap hook at one end and taped at other. specify length (RM-1761. cut length of rope only).
L950DBP 5/8" polyester. self locking snap hook at one end and seized at the other. specify length. (RM-1148. cut length of rope only).

L1364DC: 3/4" polyester/polypropylene blend. self locking snap hook at one end and taped at other. specify length (RM-1762. cut length of rope only).
L950DCP. 3/4" polyester. self locking snap hook at one end and seized at the other. specify length. (RM-1590. cut length of rope only).

Counterweight Requirements:
L1582 Rigid counterweight (6.4 lbs.)
L1583 Flexible counterweight (5.7 lbs)
(must secure/restrain lifeline)

Lanyard Requirements:
L3300DP3: 3 ft. shock absorbing lanyard
L954DAN3: 3 ft. rope lanyard
(must use 3 ft. max. length lanyard)



[illegible]00D1P3 LS-1441 rope grab with an attached EZ STOP® II shock absorbing lanyard, 3 ft. in length.

C6006

C1011

The C6006 and C1011 EVEREST Rope Grabs (Mobile Type): The C6006 operates on SR15 or SR15P 1/2" dia. (12mm) nylon or polyester lifeline and the C1011 operates on 5/16" dia. galvanized cable only. Rope grab design allows maximum mobility. Both units utilize a friction sensitive brake to lock onto the lifeline, the C6006 also incorporates a cam lever. These devices are non-detachable from lifeline. U.S. Patent No. 3,948,362. U.K. Patent No. 1,487,428. Canada Patent No. 1,049,231. France Patent No. 7,517,247.

Construction:
Size: (C6006) 7"x2" diameter. 1-1/2 lbs..
(C1011) 5-1/2"x1-5/8" diameter. 1-1/4 lbs.
Aluminum Stainless Steel

Lifeline Requirements:
SR15: 1/2" (12mm) nylon
SR15P: 1/2" (12mm) polyester
RM-1591: 5/16" diameter galvanized cable

Counterweight Requirements:
L1582: Rigid counterweight (6.4 lbs.)
L1583: Flexible counterweight (5.7 lbs.)
L172: Steel counterweight (10.7 lbs.)
(must secure/restrain lifeline)

Lanyard Requirements:
L951DAN2: 2 ft. rope lanyard
(2 ft. max. length lanyard or direct connection)

[illegible]

The [illegible] Wire Rope [illegible] (Static [illegible]): Incorporates a patented wedging action which grips and locks onto the cable lifeline. Rope grab comes with attachment ring for connecting lanyard to. The rope grab can be attached or removed anywhere along the lifeline. Patent No. 4.071.926.

Construction:
Size: 6"x3" dia., 2-3/4 lbs., Stainless Steel

Lifeline Requirements:
RM-0098 3/8" diameter 7x19 Galvanized cable
RM-0099 3/8" diameter 7x19 Stainless Steel cable
L1176-40: 40 ft. of RM-0098 with snap hook at one end, counterweight at other.

Counterweight Requirements:
L172. Steel counterweight (10.7 lbs.)
(must secure/restrain lifeline)

Lanyard Requirements:
L3300DP4 4 ft shock absorbing lanyard
L954DAN4 4 ft. rope lanyard
(must use 4 ft. max. length lanyard)

DBI/SALA
3965 Pepin Avenue,
Red Wing, MN 55066-1837
Toll Free: 800-328-6146
Phone: (612) 388-8282
Fax: (612) 388-5065

DBI/SALA Canada
Unit #14, 2 Thorncliffe Park Drive
Toronto, Ontario M4H 1H2 Canada
Toll Free: 800-205-6866
Phone: (416) 696-1500 ; Fax (416) 696-5745

Distributed By:

Form: 8/86
Rev: 6/95

Exhibit A.8: Roof Anchors for PFAS

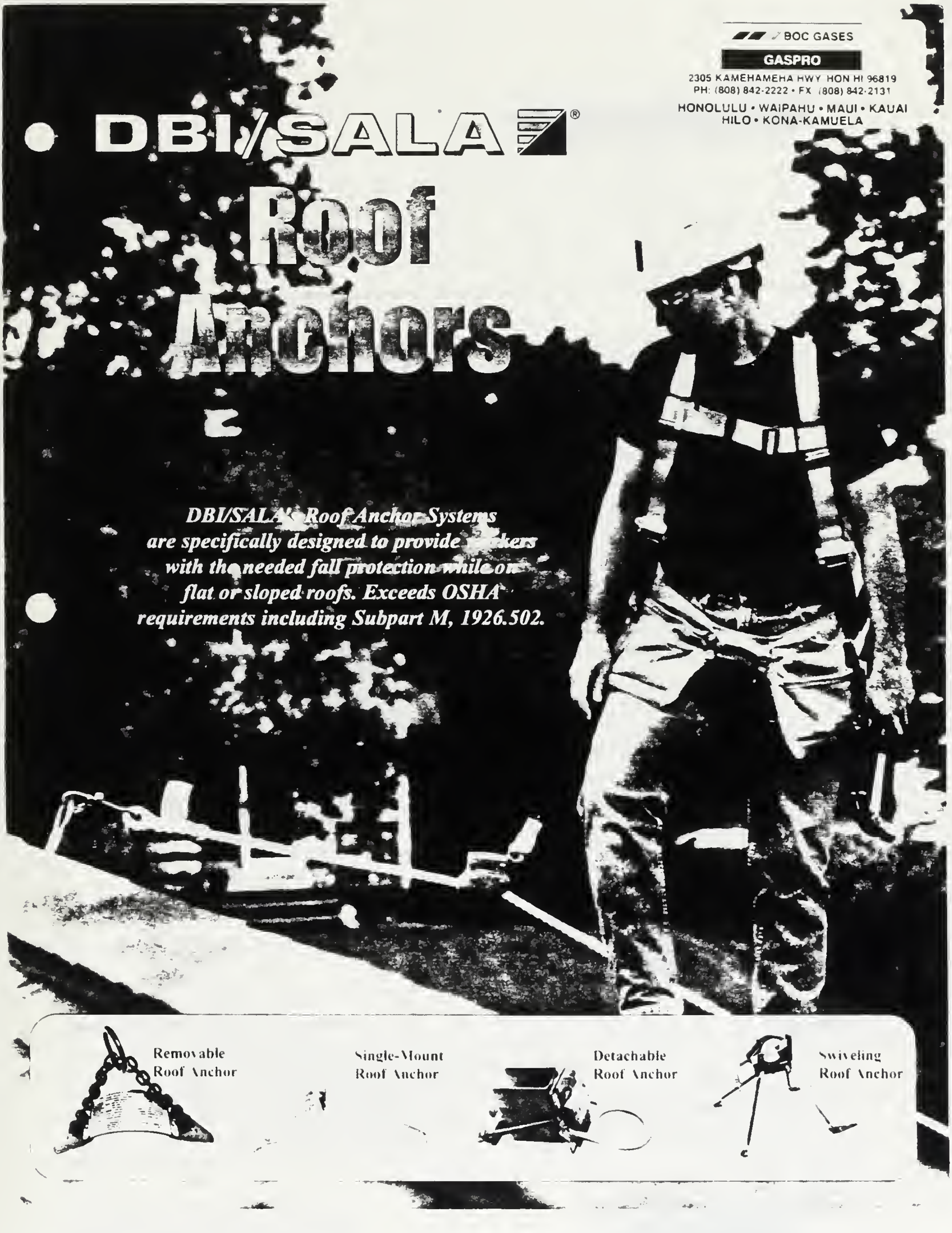
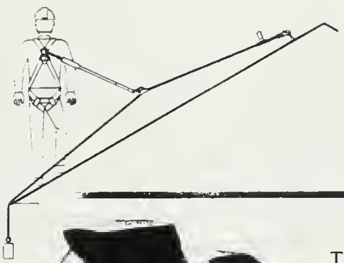


Exhibit A.8: Roof Anchors for PFAS

Roof Anchor Kits



L4168 Series Roof Anchor Fall Protection Kits

The Roof Anchor Fall Protection Kit is an easy-to-use, economical and safe way to provide workers with the needed fall protection while on flat or sloped roofs. The Kit contains everything needed in one easy to carry bag, including:

(1) Roof Anchor (select one of 4 types.)
(1) 50' Lifeline Assembly with counterweight (L4205 model).
(1) Rope adjuster with shock absorbing lanyard (L420183N3 model).
(1) Full body harness (L3513 model).
(1) Instruction set.

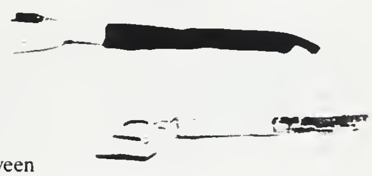
Contact DBI/SALA for harness and lifeline specifications.

All components meet OSHA and ANSI requirements including OSHA Subpart M, 1926.502. ***Individual components of the Kits may be ordered separately.***

Kits Available

L4168A - Kit with *L3673* roof anchor. Wt. = 22 lbs.
L4168B - Kit with *L3672* roof anchor. Wt. = 19.4 lbs.
L4168F - Kit with *L4540* roof anchor. Wt. = 19.2 lbs.
L4168G - Kit with *L4541* roof anchor. Wt. = 19.5 lbs.
L4168H - Kit with *L4542* roof anchor. Wt. = 19.9 lbs.

L420183N3 Rope Adjuster

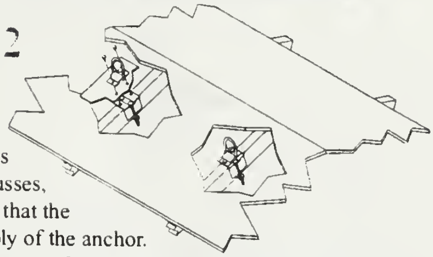


This rope adjuster with an attached 3 ft. shock absorbing lanyard is designed to be a static rope grab that is the connecting lanyard between the full body harness and the lifeline. By compressing the rope adjuster forward, the worker can slide the L420183N3 along the lifeline until he or she has reached their work position. Release the rope adjuster and it locks onto the lifeline providing fall protection to the worker attached. ***The L420183N3 may be ordered separately from the Roof Anchor Kits.***

Overall Length = 42", Wt. = 1.4 lbs.
Minimum Breaking Strength = 5,000 lbs.

Detachable Roof Anchor

L4540, L4541 & L4542 Roof Anchors



The detachable style roof anchors are designed to provide workers with a fall protection system roof anchor that connects to open trusses, joists, and rafters. The advantage to the detachable roof anchor is that the D-ring assembly is detachable, leaving behind the bottom assembly of the anchor. The bottom assembly can be shingled over leaving nothing sticking out of the roof above the shingles. The detachable D-ring assembly (D-ring, top bracket and 2 bolts) can then be reattached to a different body unit at another site. Complete with flashing to prevent water leakage through the roof during construction. Meets OSHA requirements including Subpart M, 1926.502.

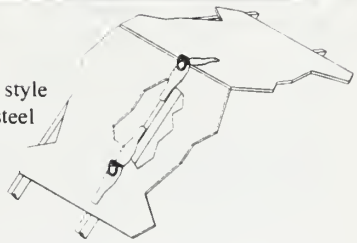
Models Available

L4540: Fits 2x4 roof truss, joist, rafter.
L4541: Fits 2x6 and 2x8 roof truss, joist, rafter.
L4542: Fits 2x10 and 2x12 roof truss, joist, rafter.
L4517: Top D-ring assembly (fits all bottom brackets).
L4534: Bottom assembly (fits 2x4s).
L4535: Bottom assembly (fits 2x6 and 2x8).
L4536: Bottom assembly (fits 2x10 and 2x12).

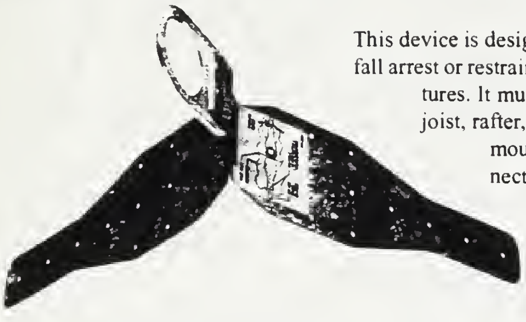
Size = (L4540) 3.625"x3.2"x9.75" (L4541) 3.625"x3.2"x13.75" (L4542) 3.625"x3.2"x17.75", Wt. = (L4540) 2.0 lbs. (L4541) 2.25 lbs. (4542) 2.5 lbs., Minimum Breaking Strength = 5,000 lbs.

Single-Mount Roof Anchor

L3672 Roof Anchor



This is a single mount (16 gauge double sided galvanized sheet metal) style roof anchor that comes complete with a cadmium plated forged alloy steel D-ring (fall arrest or restraint connection point), product labeling and complete instructions. Meets OSHA requirements including Subpart M, 1926.502.



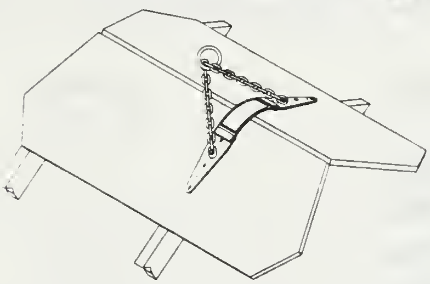
This device is designed to be an anchorage connector for personal fall arrest or restraint systems used on flat or sloped wood roof structures. It must be nailed (16d [penny]) into the sheathing and joist, rafter, etc. (roof member). Specifically designed to be mounted only once (ie. remove and destroy or cut connecting D-ring off and shingle over).

Length When Flat = 22" • Wt. = 1.8 lbs.
Minimum Breaking Strength = 5,000 lbs.

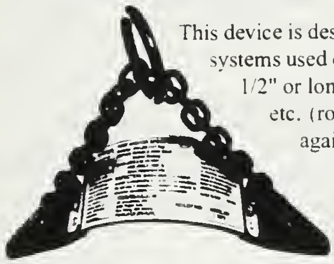
DBI/SALA

800-328-6146

Removable Roof Anchor



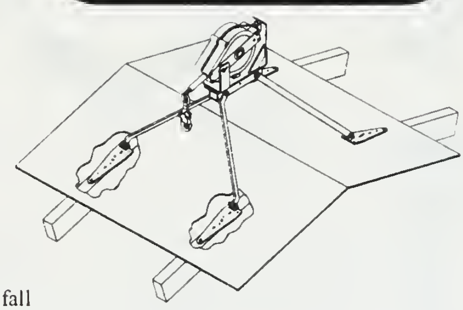
This is a removable (1/4" thick steel) style roof anchor that comes complete with a zinc plated forged alloy steel O-ring (fall arrest or restraint connection point), product labeling and complete instructions. Meets OSHA requirements including Subpart M, 1926.502.



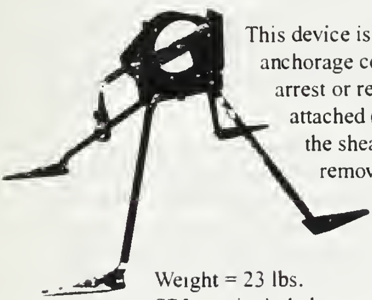
This device is designed to be an anchorage connector for personal fall arrest or restraint systems used on flat or sloped wood roof structures. It must be attached (Six 1/4"x2-1/2" or longer lag screws or twelve 16d nails) into the sheathing and joist, rafter, etc. (roof member). Specifically designed to be removable, it may be used again after an inspection (refer to instructions).

Overall Length When Flat = 25" • Wt. = 4.4 lbs.
Minimum Breaking Strength = 5,000 lbs.

Swiveling Roof Anchor



This swiveling roof anchor bracket is designed to anchor a self retracting lifeline that is capable of rotating 360°, giving workers maximum freedom of movement. Meets OSHA requirements including Subpart M, 1926.502.



This device is designed to be an anchorage connector for personal fall arrest or restraint systems used on flat or sloped wood roof structures. It must be attached (Twelve 1/4"x2-1/2" or longer lag screws or twenty-four 16d nails) into the sheathing and joist, rafter, etc. (roof member). Specifically designed to be removable, it may be used again after an inspection (refer to instructions).

Weight = 23 lbs.
SRL not included

Models Available:

L5682: Swiveling roof anchor (self retracting lifeline not included).
L5694: Swiveling roof anchor with 30' self retracting lifeline.
L5695: Swiveling roof anchor with 50' self retracting lifeline.

Swiveling roof anchor is design to be used with DBI/SALA self retracting lifeline models L4430 and L4450 only. Strength of system maintains minimum safety factor of 2 when used according to instructions. *(Ref. OSHA 1926.502).*

DBI/SALA

3965 Pepin Avenue, Red Wing, MN 55066-1837 • Toll Free: 800-328-6146 • Phone: (612) 388-8282 • Fax: (612) 388-5065

Unit #6, 825 Middlefield Road • Scarborough, Ontario M1V 4Z7 Canada • Toll Free: 800-205-6866 • Phone: (416) 321-0079 • Fax: (416) 321-6601

Form 1/94B
Rev 11/96

Exhibit A.9: Full Body Harnesses for PFAS

DBI/SALA®

Full Body Harnesses

DBI/SALA is committed to lead the safety industry into the future by providing you with the highest quality fall protection technology, technical assistance, support, servicing and training.

DBI/SALA offers the most complete range of Full Body Harnesses known to the industry.

The industry has aked for and expected a wide variety of options and styles, and DBI/SALA has answered by designing Full Body Harnesses to suit particular needs.

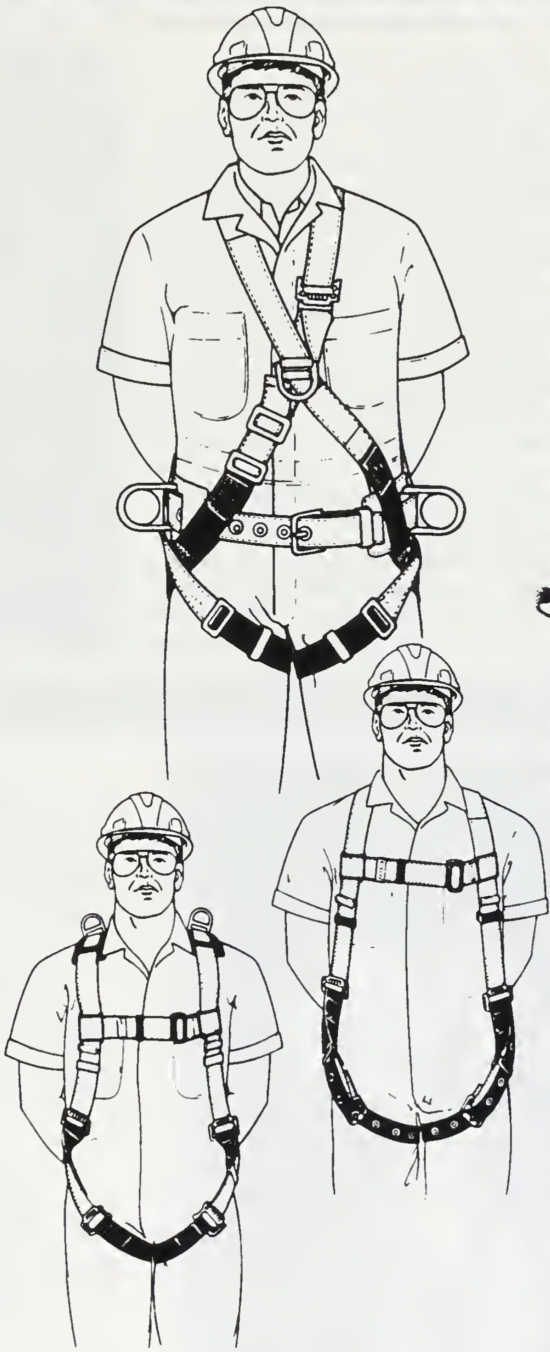
Whether your particular need is for fall arrest, restraint, work positioning, ladder climbing or rescue, we have a Full Body Harness that was designed and manufactured in the U.S.A. for you.

Design options include: patented cross-over style, vest style, conventional style, european style, lightweight, high visibility, flame resistant, nonsparking hardware, support straps, back D-ring, side D-rings, front D-ring, shoulder D-rings, body belt, loops for body belt, parachute buckles, tongue buckles, metal to metal pass through buckles and many, many more........................

DBI/SALA Full Body Harnesses were designed and manufactured with one thing in mind, second to none worker safety.

During a fall, the workers safety is of utmost importance. These Full Body Harnesses were designed to retain the worker in the event of a fall and distribute the impact forces throughout the thighs, buttocks, chest and shoulders and allow for maximum freedom of movement and piece of mind.

You can have piece of mind knowing that DBI/SALA Full Body Harnesses were manufactured to meet or exceed applicable industry standards including ANSI A10.14-1991, ANSI Z359.1-1992 and OSHA regulations.



SALA DBI/SALA DBI/SALA DBI/S

L3521 Full Body Harness (Cross-Over Construction Style):

This Full Body Harness features a Patented Cross-Over design with leather hip pad for additional back support and body belt to carry tools, pouches, etc. Harness comes complete with adjustable front D-ring *(used for work positioning or ladder climbing)*, and a back D-ring *(used for fall arrest or restraint)*. The leather hip pad comes complete with side D-rings *(used for restraint or work positioning)*. The waist belt is a tongue buckle type.

Complete with metal to metal pass through type adjuster buckles on lower chest and leg straps and must be ordered by size: L3521-2 (small), L3521-3 (medium), L3521-4 (large), and L3521-5 (X-large). Polyester webbing. Wt. = 5.2 lbs.

L3511 Full Body Harness (Cross-Over Construction Style):

This Full Body Harness is the same as the L3521 except it does not come with leather hip pad and body belt but includes loops to accomodate 3" max. width body belt. Universal sizing. Wt. = 2.6 lbs.

Cross-Over Construction Style • Cross-Over Construction Style

L3518 Full Body Harness (Cross-Over Construction Style):

This Full Body Harness is the same as the L3521 except the leather hip pad does not have side D-rings. Order by size (see above). Wt. = 4.4 lbs.

L3520 Full Body Harness (Cross-Over Construction Style):

This Full Body Harness is the same as the L3521 except the harness has side D-rings and the leather hip pad does not. Order by size (see above). Wt. = 5.2 lbs.

L3510 Full Body Harness (Cross-Over Construction Style):

This Full Body Harness is the same as the L3520 except it does not come with leather hip pad and body belt but includes loops to accomodate 3" max. width body belt. Universal sizing. Wt. = 3.2 lbs.

L3523 Full Body Harness (Vest-Type Construction Style):
This Full Body Harness features a Vest-Type design with leather hip pad for additional back support and body belt to carry tools, pouches, etc. Harness comes complete with back D-ring *(used for fall arrest or restraint)*. The Leather hip pad comes complete with side D-rings *(used for restraint or work positioning)*. The waist belt is a tongue buckle type.

Complete with chest strap, parachute adjuster buckles on lower chest, metal to metal pass through type adjuster buckles on leg straps and must be ordered by size: L3523-2 (small), L3523-3 (medium), L3523-4 (large), and L3523-5 (X-large). Polyester webbing. Wt. = 5.0 lbs.

L3519 Full Body Harness (Vest-Type Construction Style):
This Full Body Harness is the same as the L3523 except the leather hip pad does not have side D-rings. Order by size (see above). Wt. = 4.4 lbs.

Vest-Type Construction Style • Vest-Type Construction Style

L3513 Full Body Harness (Vest-Type Construction Style):
This Full Body Harness is the same as the L3523 except it does not come with leather hip pad and body belt but includes loops to accomodate 3" max. width body belt. Universal sizing. Wt. = 2.4 lbs.

L3522 Full Body Harness (Vest-Type Construction Style):
This Full Body Harness is the same as the L3523 except the leather hip pad does not have side D-rings, but the harness does. Order by size (see above). Wt. = 5.0 lbs.

L3512 Full Body Harness (Cross-Over Construction Style):
This Full Body Harness is the same as the L3522 except it does not have a leather hip pad and body belt but includes loops to accomodate 3" max. width body belt. Universal sizing. Wt. = 3.1 lbs.

Exhibit A.9: Full Body Harnesses for PFAS

L3803 Full Body Harness (Vest-Type Flame Resistant Style):

Features a flame resistant 100% Kevlar® 29 webbing design and is Black BR Treated to minimize U.V. degredation and to provide abrasion resistance.

Harness comes complete with back D-ring *(used for fall arrest)*, pass thru (metal to metal) adjuster buckles on leg straps, parachute adjuster buckle on shoulder straps (hardware is cadmium plated forged alloy steel). Univ. siz. Wt. = 3.5 lbs.

L3804 Full Body Harness (Vest-Type Flame Resistant / Nonsparking Style):

Same as above except with Nonsparking high strength Beryllium Copper hardware. Wt. = 3.8 lbs.

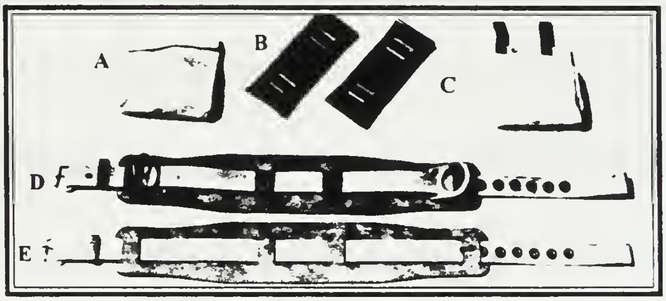
L3805 Full Body Harness (Vest-Type Nonsparking Style):

Same as L3804 except with standard polyester webbing. Wt. = 3.0 lbs.

Specifications: 1-3 4" Kevlar® 29 webbing; black BR treated. 800°F char temperature (withstands limited exposure to 1000°F). exceptional cut resistance. Beryllium Copper or Copper Alloy Hardware: non- sparking, heat treated, nonmagnetic, corrosion resistant. Buckles have a 4,000 lbs. minimum breaking strength, and the D-rings have a 5,000 lbs. minimum breaking strength. Meets ANSI A10.14-1991 and OSHA 1910.66. Kevlar is a registered trademark of DuPont

Accessories

A) L892: Pouch with belt loops and velcro closure.
B) L3710: Shoulder pad, 1/2" thick neoprene, velcro loop closure. 10" long x 4" wide.
C) L890: Pouch with belt loops and snap closure
D) L3460: Leather hip pad with side D-rings. **L3460-3 for Sm. & Med. belts and harnesses, L3460-5 for Lg. & XLg belts and harnesses. Shown with LB910 tongue buckle body belt.**
E) L3461: Same as L3460 except does not have side D-rings. Order by size (see above).
NOTE: LB910 must be ordered by size: 32"-40" waist (Sm.), 36"-44" waist (Med.), 40"-48" waist (Lg.), 44"-52" waist (XLg.)



Technical Data

Webbing:

RM-1751 yellow polyester 1-3/4" for upper body (6,000 lbs. min. tensile strength)
RM-1752 black polyester 1-3/4" for lower body (6,000 lbs. min. tensile strength)
RM-3608 neon orange polyester 1-3/4" for HV harnesses (6,000 lbs. min. tensile strength)
RM-1298 yellow polyester 1-3/4" for LB910 body belt and L1205 L1705 (8,800 lbs. min. tensile strength)
RM-1278 black polyester 3" for back support for L1632 (2,575 min. tensile strength)
RM-1212 yellow polyester 2" for waist belts on L1205SB, L1205SS, L1705PB, L1705PS (12,000 lbs. min. tensile strength)

Stitching:

Size No. 346 bonded polyester thread. 5 to 7 stitches per inch, high strength

Hip Pad:

RM-3458 RM-3459 two plies 5" wide 6 oz. full grain leather
RM-3463 polyethelene stiffener. 1 16" thick

Hardware:

0901-020 cadmium plated forged alloy steel back and side D-rings (5,000 lbs. min. tensile strength)
RM-1008 cadmium plated forged alloy steel front D-ring and shoulder D-rings (5,000 lbs. min. tensile strength)
RM-1409 cadmium plated forged alloy steel adjuster link for front D-ring and subpelvic strap buckle on L1631 L1632 (4,000 lbs. min. tensile strength)
RM-0995-1 cadmium plated alloy steel parachute adjuster buckle (4,000 lbs. min. tensile strength)
RM-3224 RM-3225 zinc plated alloy steel leg and chest strap buckles (4,000 lbs. min. tensile strength)
RM-0931 cadmium plated forged alloy steel tongue buckle (4,000 lbs. min tensile strgth.)
RM-3506 zinc plated steel keeper buckles
RM-1634 galvanized alloy steel O-ring subpelvic retainer on L1631 L1632 (9,000 lbs. min. tensile strength)

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Fax (612) 388-5065

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Toronto, Ontario M4H 1H2 Canada
Phone. (416) 696-1500 ; Fax. (416) 696-5745

Form: 9/93

Appendix B: Job Site Photographs

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Figure B.1: Partial reroofing project, Aiea; no protection in use

Figure B.2: Reroofing job, Marine Corps Base Hawaii, Kaneohe; PFAS in use

Figure B.3: Finish work, central Oahu; no protection

Figure B.4: Renovation project, Honolulu; no protection

Figure B.5: New construction, Ewa Beach; PR20 Eave Catchguard system and Trus-T PFAS variant, end view

Figure B.6: New construction, Ewa Beach; PR20 Eave Catchguard system and Trus-T PFAS variant, corner view

Figure B.7: New construction, Ewa Beach; finished roof with permanent Trus-T anchor system installed on ridge (Note slightly raised portion of ridge cap; Trus-T anchors are spaced evenly along ridge in this raised portion.)

Figure B.8: Renovation project, Hickam Air Force Base; fall protection plan (Note improper work platform and lack of fall protection.)

Figure B.9: Renovation project, Hickam Air Force Base; fall protection plan (Note "controlled access zone" sign at left front corner of structure.)

Figure B.10: Renovation project, Hickam Air Force Base; fall protection plan (Note access to roof.)

Figure B.11: New construction, Moanalua Navy Family Housing, Pearl Harbor; Safe-T-Strap PFAS variant (Note strap attached to worker's PFAS.)

Figure B.12: New construction, Moanalua Navy Family Housing, Pearl Harbor; Safe-T-Strap PFAS variant (Note strap attached to worker's PFAS.)

Figure B.13: New construction, Moanalua Navy Family Housing, Pearl Harbor; Safe-T-Strap PFAS variant (Note strap hanging from ridge and proceeding down to right.)

Figure B.14: New construction, Moanalua Navy Family Housing, Pearl Harbor; use of alternative construction sequence to allow for placement of work platforms during truss installation (Note lack of interior frame walls.)

Figure B.15: New construction, Moanalua Navy Family Housing, Pearl Harbor; guardrail system used in siding operations

Figure B.16: New construction, Child Development Center, Marine Corps Base Hawaii, Kaneohe; use of scaffolds for finish work

Figure B.17: New construction, Child Development Center, Marine Corps Base Hawaii, Kaneohe; PFAS use (Note the anchorage for the worker's PFAS--a vent pipe!)

Figure B.18: New construction, central Oahu; fall protection plan; setting the center ridge for half-truss installation (No protection is afforded to the worker.)

Figure B.19: New construction, central Oahu; fall protection plan; truss delivery and placement on the top plates of frame walls (No protection is afforded to the worker.)

Figure B.20: New construction, central Oahu; fall protection plan; trusses spaced in bundles along top plate for installation by framers

Figure B.21: New construction, central Oahu; fall protection plan; truss installation--setting the trusses

Figure B.22: New construction, central Oahu; fall protection plan; truss installation--walking the top plate

Figure B.23: New construction, central Oahu; fall protection plan; truss installation--bracing the trusses

Figure B.24: New construction, central Oahu; prefabrication; prefabricated floor joist system, ready for lifting

Figures B.25 and B.26: New construction, central Oahu; prefabrication; lifting and placing the prefabricated floor joist system

Figure B.27: New construction, central Oahu; prefabrication; prefabricated truss system

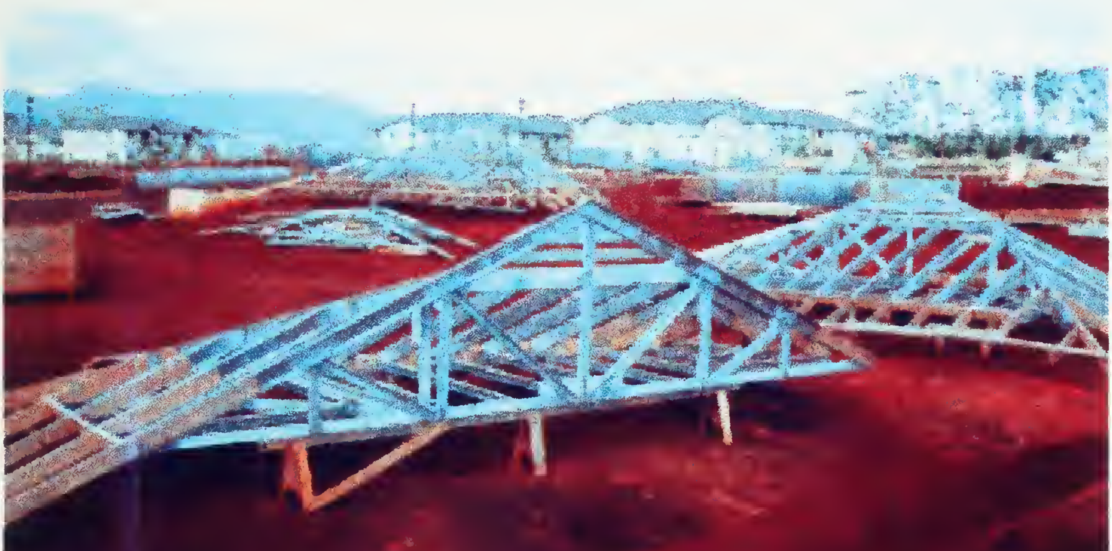

Figure B.28: New construction, central Oahu; prefabrication; prefabricated truss systems

Appendix C: Sample Fall Protection Plans

Contents

Fall Protection Plan for Residential Construction

This Fall Protection Plan Is Specific For The Following Project:

Location of Job:	Area 26
Date Plan Prepared	April 15, 1996
Date Revised:	
Plan Prepared By:	____________________
Plan Approved By:	____________________
Plan Supervised By:	____________________

PURPOSE:

The purpose of this plan is to provide a site specific supplement to our existing safety and health program and to ensure that every employee who works for ______________ ___ recognizes workplace fall hazards and takes the appropriate measures to address those hazards. The following Fall Protection Plan is prepared for the prevention of injuries associated with falls in areas where conventional means of fall protection are infeasible and/or create a greater hazard.

INTRODUCTION:

During the construction of residential buildings under 48 feet in height, it is sometimes infeasible or it creates a greater hazard to use conventional fall protection systems at specific areas or for specific tasks. This Fall Protection Plan addresses the use of conventional fall protection at a number of areas on the project, as well as identifies specific activities that require non-conventional means of fall protection.
The areas or tasks include, but are not limited to:

a. Setting and bracing of roof trusses and rafters;
b. Installation of floor sheathing, joists and blocks;
c. Floor sheathing operations;
d. Roof sheathing;
e. Upper floor framing;

In these cases, conventional fall protection systems may not be the safest choice for workers. This plan is designed to enable employers and employees to recognize the fall hazards associated with this job and to establish the safest procedures that are to be followed in order to prevent falls to lower levels or through holes and openings in walking/working surfaces.

Each employee will be trained in these procedures and will strictly adhere to them except when doing so would expose the employee to a greater hazard. If, in the employee's opinion, this is the case, the employee is to notify the competent person of their concern and have the concern addressed before proceeding.

It is the responsibility of ____________ to implement this Fall Protection Plan. Continual observational safety checks of work operations and the enforcement of the safety policy and procedures shall be regularly enforced. The crew foremen, ____________ and ______________, are responsible for correcting any unsafe practices or conditions immediately. It is the responsibility of the employer to ensure that all employees understand and adhere to the procedures of this plan and to follow the instructions of the crew foreman.

It is also the responsibility of the employee to bring to management's attention any unsafe or hazardous conditions or practices that may cause injury to either themselves or any other employees. Any changes to the Fall Protection Plan must be approved by ______________.

I. STATEMENT OF COMPANY POLICY:

______________ is dedicated to the protection of its employees from on-the-job injuries. All employees of ______________ have the responsibility to recognize fall hazards, take appropriate action to protect themselves from fall exposures, and to work safely on the job.

II. FALL PROTECTION SYSTEMS TO BE USED ON THIS JOB:

Installation of roof trusses/rafters, exterior wall erection, roof sheathing, floor sheathing and joist/truss activities will be conducted by employees who are specifically trained to do this type of work and are trained to recognize the fall hazards. The nature of such work normally exposes the employee to the fall hazard for a short period of time. This Plan details how ______________ will minimize these hazards.

Controlled Access Zones: 1926.502 (g)

When using the Plan to implement the fall protection options available, workers must be protected through limited access to high hazard locations. Before any non-conventional fall protection systems are used as part of the work plan, a controlled access zone (CAZ) shall be clearly defined by the competent person as an area where a recognized hazard exists. The demarcation of the CAZ shall be communicated by the competent person in a recognized manner, either through signs, wires, tapes, ropes or chains. ______________ shall take the following steps to ensure that the CAZ is clearly marked or controlled by the competent person:

All access to the CAZ must be restricted to authorized entrants;
All workers who are permitted in the CAZ shall be listed in the appropriate sections of the Plan (or be visibly identifiable by the competent person) prior to implementation;
The competent person shall ensure that all protective elements of the CAZ be implemented prior to the beginning of work.

Installation Procedures for Roof Truss and Rafter Erection

During the erection and bracing of roof trusses/rafters, conventional fall protection may present a greater hazard to workers. On this job, safety nets, guardrails and personal fall arrest systems will not provide adequate fall protection because the nets will cause the walls to collapse, while there are no suitable attachment or anchorage points for guardrails or personal fall arrest systems.

Exterior scaffolds cannot be used on this job because the ground, after recent backfilling cannot support the scaffolding. In most cases, the erection and dismantling of the scaffold would expose the workers to a greater fall hazard than erection of the trusses/rafters.

In structures that have walls higher than eight feet and where the use of scaffolds and laddres would create a greater hazard, safe working procedures will be utilized when working on the top plate and will be monitored by the crew supervisor. During all stages of the truss/rafter erection the stability of the trusses/rafters will be ensured at all times.

On this job, requiring workers to use a ladder for the entire installation process will cause a greater hazard because the worker must stand on the ladder with his back or side to the front of the ladder. While erecting the truss or rafter the worker will need both hands to maneuver the truss and therefore cannot hold onto the ladder. In addition, ladders cannot be adequately protected from movement while trusses are being maneuvered into place. Many workers may experience additional fatigue because of the increase in overhead work with heavy materials, which can also lead to a greater hazard.

________________ shall take the following steps to protect workers who are exposed to fall hazards while working from the top plate installing trusses/rafters:

Only the following trained workers will be allowed to work on the top plate during roof truss or rafter installation:

Workers shall have no other duties to perform during truss/rafter erection procedures;

All trusses/rafters will be adequately braced before any worker can use the truss/rafter as a support;

Workers will remain on the top plate using the previously stabilized truss/rafter as a support while other trusses/rafters are being erected;

Workers will leave the area of the secured trusses only when it is necessary to secure another truss/rafter;

The workers responsible for detaching trusses from cranes and/or securing trusses at the peaks traditionally are positioned at the peak of the trusses/rafters. There are also situations where workers securing rafters to ridge beams will be positioned on top of the ridge beam. Personal fall arrest systems will be used.

________________ shall take the following steps to protect workers who are exposed to fall hazards while securing trusses/rafters at the peak of the trusses/ridge beam:

Only the following trained workers will be allowed to work at the peak during roof truss or rafter installation:

Once truss or rafter installation begins, workers not involved in that activity shall not stand or walk below or adjacent to the roof opening or exterior walls in any area where they could be struck by falling objects;

Workers shall have no other duties than securing/bracing the trusses/ridge beam;

Workers positioned at the peaks or in the webs of trusses or on top of the ridge beam shall work from a stable position, either by sitting on a "ridge seat" or other equivalent surface that provides additional stability or by positioning themselves in previously stabilized trusses/rafters and leaning into and reaching through the trusses/rafters;

Workers shall not remain on or in the peak/ridge any longer than necessary to safely complete the task.

<u>Installation of Floor Joist & Sheathing</u>

During the installation of floor sheathing/joists (leading edge construction), the following steps shall be taken to protect workers;

Only the following trained workers will be allowed to install floor joists or sheathing:

Materials for the operations shall be conveniently staged to allow for easy access to workers.

Exhibit C.1: Plan #1

Construction of Exterior Walls and
Applicable Interior Walls with 6 Foot Fall Exposure

During the construction and erection of exterior walls, the following steps shall be taken to protect the workers; only the following trained workers will be allowed to erect exterior walls:

Materials for operations shall be conveniently staged to minimize fall hazards; and workers constructing exterior walls shall complete as much cutting of materials and other preparation as possible away from the edge of the deck.

III. Enforcement

Constant awareness of and respect for fall hazards, and compliance with all safety rules are considered conditions of employment. The crew supervisor or foreman, as well as individuals in the Safety and Personnel Department, reserve the right to issue disciplinary warnings to employees, up to and including termination, for failure to follow the guidelines of this program.

IV. Accident Investigations

All accidents that result in injury to workers, regardless of their nature, shall be investigated and reported. It is an integral part of any safety program that documentation take place as soon as possible so that the cause and means of prevention can be identified to prevent a reoccurrence. In the event that an employee falls or there is some other related, serious incident occurring, this plan shall be reviewed to determine if additional practices, procedures, or training need to be implemented to prevent similar types of falls or incidents from occurring.

V. Changes to Plan

Any changes to the plan will be approved by ____________. This plan shall be reviewed by a qualified person as the job progresses to determine if additional practices, procedures or training needs to be implemented by the competent person to improve or provide additional fall protection. Workers shall be notified and trained, if necessary, in the new procedures. A copy of this plan and all approved changes shall be maintained at the jobsite.

____

Exhibit C.2: Plan #2

FALL PROTECTION PLAN FOR ________________

Table of Contents

JOB NAME

a. This fall protection plan is for (______________________________)

b. Location : Project is located in ______ of the Island of Oahu, Hawaii

c. Date of Plan: 2/23/96

d. Prepared by (_____________, Project Coordinator)

e. Approved by : (______________________________) Date: (__________)

f. Plan supevised by : (____)

Introduction: This is ________________ **FALL PROTECTION PLAN** . It has been adopted to meet the requirements of 29 C.F.R. 1926.500, the OSHA standard that was adopted on Feb. 6, 1995, in order to protect employees in the construction industry from falls whenever workers are exposed to a fall of six feet or more. All our affected employees have been advised of this written plan. The plan will be available for inspection by our employees and their authorized representatives upon request.

This plan applies to all our employees who find they cannot use conventional fall protection equiptment. The purpose of this plan is to ensure that all our employees are protected against fall hazards while working in residental, commercial, roofing work. The company is committed to a safe and accident-free jobsite.

Company Policy:

is dedicated to the protection of its employees from on the job injuries . All employees of our company have the responsiblility to work safely on the job.

The purpose of this plan is: (a.) to supplement our standard safety policy by providing sagety standards specifically designed to cover fall protection on this job, and (b.) to ensure that each employee is trained and made aware of the safety provisions that are to be implemented by this plan prior to the start of construction.

This Fall Protection Plan addresses the use of other than conventional fall protection at a number of areas on the project. It also identifies specific activities that require no -conventional means of fall protection.

These ares include:

— Unprotected sides or edges
— Ridge Tie off

This plan is designed to enable employees to recognize the **fall hazards on this job and to establish the procedures that are ot be followed in order to prevent falls to lower levels or through holes and openings in roof walking surfaces.** Each employee will be trained in these procedures and strictly adhere to them except when doing so would expose the employee to a greater hazard . If, in the employee's opinion, this is the case, the employee is to notify the foreman of the concern, and the concern is to be addressed before proceeding.

Safey policy and procedure on any one project cannot be administered , implemented, monitored and enforced by any one individual. The total objective of a safe, accident - free work enviornment can be accomplished only by a dedicated, concerted effort by every individual involved with the project.

Each employee must understand:

— His or Her value to the company
— The costs of accidents, both monetary , physical and emotional.
— The objective of the safety policy and procedures.
— The safety rules that apply to the safety policy and procedures.
— His or her role in administering, implementing, monitoring , and complying with safety policy procedures.

This allows for a more personal approach to compliance through planning, training, understanding and cooperative effort, rather than strict enforcement. If for any reason an unsafe act persists, strict enforcement will be implemented.

It is the responsiblity of ______________________ to implement this Fall Protection Plan.
______________ is responsible for continued observational safety checks of work operations and enforcement of the safety policy and procedures.

The foreman also is responsible to correct any unsafe acts or conditions immediately. It is the responsibility of the employee to understand and adhere to the procedures of this plan and to the follow the instructions of the foreman . It is also the responsibility of the employee to bring to management's attention any unsafe or hazardous conditions or acts that may cause injury to either themselves or any other employees.

Training

We have adopted an employee training program so that all employees who will be exposed to fall hazards will acquire the understanding , knowledge and skills necessary for the safe performance of their assigned duties.

Training will be provided to each employee. We will ensure that each employee has been trained by a compentent person qualified in the following areas:

1} The nature of fall hazards in the work area.
2} The correct procedures for erecting, maintaining , disassembling and inspection the fall protection system to be used.
3} The use and operation of guardrail systems, personal fall arrest systems to be used.
4} The limitations on the use of mechanical equipment during the performance of roofing work on low-sloped roofs.
5} The correct procedures for the handling and storage of equipment and materials.

The training must be conducted in a manner that will establish employee proficiency in the duties required by OSHA standard. It will cover the various systems and procedures we have adopted. It also will introduce new or revised procedures, as necessary , in order to accpmplish full compliance with the fall protection standard.

Upon its completion, we will execute a written certification that the training required by the OSHA standard has been accomplished. The certification will contain each employee's name, the signatures or initials of the trainers , and the dates of the training. The certification will be availible for inspection by employees and their authorized repesentatives at the local jobsite office.

Conventional Fall Protection Systems

In this roofing sequence and procedure, personal fall arrest systems requiring body belt / harness system , lifelines and lanyards,or retractable devise will be sufficent for the installation of the roofing work for this project.

When using a retractable devise , when necessary to move away from a retractable devise, the worker cannot move at a rate greator than the device -locking speed, typically 3.5 to 5 feet per second. When moving toward the device, it is necessary to move at a rate that does not permit cable slack to build up. This slack may cause cable retraction acceleration and cause a worker to lose his or her balance by applying a higher than normal jerking force on the body when the cable suddenly becomes taut after building up momentum. This slack also can cause damage to the internal spring-loaded drum, uneven coiling of cable on the drum, and possible cable damage.

The factures causing sudden movements for this location include:

(a.) Cranes
1. Operator error 2. Site conditions (soft or unstable ground) 3. Mechanical failure.
4. Structural failure. 5. Rigging failure. 6. Crane signal /radio communication failure.

(b.) Weather Conditions
1. Wing (strong wind /sudden gusting) -- particularly a problem with the long metal roofing panels.
2. Snow /rain (visiblity) 3. Fog (visibility) 4. Cold --causing slowed reactions or mechanical problems.

(c.) Structure/ Product Conditions
1 Lifiting eye failure 2. Bearing failure of slippage 3. Structure shifting 4. Bracing failure.
5. Product failure.

(d.) Human Error
1. Incorrect slack in line procedure. 2. Safety Line hang up. 3. Incorrect or misunderstood hand signals. 4. Misjudged elevation of sheet metal or other product. 5. Misjudged speed of materials. 6. Misjudged angle of materials.

Exhibit C.2: Plan #2

For Wood Sheating Roof Structures:
All tie off spots: ______________ will supply metal ridge straps that can be bolted or nailed into the existing Wood rafters or the Steel rafters. All lifelines will accompany the Ridge Straps and men will tie off to this Life Line.

We will list the **American National Standard for Construction and Demolition Operations** – Requirments for Safety Belts , Harnesese, Lanyards and Lifelines for Construction and Demolition Use. **Note! No pages that to follow that apply to this particular job site:** Pages - .

Enforcment :

Constant awareness of and respect for fall hazards, and compliance with all safety rules are considered conditions of employment. The jobsite superintendent, as well as individuals in the safety and personnel department, reserve the right to issue disiciplinary warnings to employees,up to and including termination, for failure to follow the guidelines of this plan.

Date of Infraction: ____________
Name of Enforcement personell:____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____

Date of Infraction: ____________
Name of Enforcement personell:____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____
Name of Employee: ____

Accident Investigations:

All accidents that result in injury to workers, regardless of their nature, will be investigated and reported. It is an integral part of any safety program that documentation take place as soon as possible so that the cause and means of prevention can be identified to prevent a reoccurence.

In the event that an employee falls or there is some other related , serious incident occurring, this plan will be reviewed to determine if additional practices , procedures , or training need to be implemented to prevent similar types of falls or incidents from occuring.

A written report of the accidents will be provided by the foreman within 24hrs. of the accident that witnessed the accident.

Changes to this Plan :

This plan will be reviewed by a qualified person as the job progresses to determine if additional practices, procedures or training need to implemented by the competent person to improve or provide additional fall protection. Workers will be notified and trained , if necessary, in the new procedures. A copy of this plan and all the approved changes will be maintained at the jobsite.

<u>Any changes to the plan will be approved by: ______________, Project Coordinator</u>

Exhibit C.3: Plan #3

FALL PROTECTION PLAN

January, 1997

Plan Supervised by: _______________, Project Superintendent

I. Statement of Company Policy

__________________________ is dedicated to the protection of its employees from on the job injuries. All employees of the company have the responsibility to work safely on the job. The purpose of this plan is to supplement our standard safety policy by providing safety standards specifically designed to cover fall protection on this job and to ensure that each employee is trained and made aware of the safety provisions which are to be implemented by this plan prior to the trusses being raised.

This Fall Protection Plan identifies specific activities that require non-conventional means of fall protection and specifically addresses unprotected sides or edges.

This plan is designed to enable us to recognize the fall hazards on this job and to establish the procedures that are to be followed in order to prevent falls to lower levels because of an unprotected side. Each employee will be trained in these procedures and will strictly adhere to them unless, by doing so they would be exposed to a greater hazard. If, in the employees' opinion, this is the situation, he is to notify his supervisor of his concern and it will be addressed before proceeding.

It is the responsibility of _______________ to implement this Fall Protection Plan. The designated crew leader will be responsible for continual safety checks of their work operation and to enforce the safety policy and procedures.

II. Workers exposed:

III. Fall Protection Systems to Be Used on This Project

During truss work, the fall protection for workers at the leading edge shall be assured by a safety monitoring system and supplemented by control lines to ensure the safety of all those working within the unprotected area. All standard fall protection precautions will be followed wherever feasible.

There will be a crew selected specifically for setting the tritees. The crew will be trained for this task and will be working closely with each other. The crew will remain the same for the duration of the precast setting at the jobsite.

The duties of the safety monitor, are to:

- Warn by voice when approaching the open edge in an unsafe manner
- make the designated setters aware they are in a dangerous area
- be competent in recognizing fall hazards
- be on the same walking surface as the monitored employees and within visual sighting distance of the monitored employees.
- be close enough to communicate orally with the employees
- not allow other responsibilities to encumber monitoring. If so, he will turn over the safety monitoring function to another designated, competent person.
- All members of the setting crew will be trained in the job of safety monitor should the named safety monitor be unable to perform his duties for any reason.

IV. Training

All those on the setting crew will be instructed to wear their personal fall protection equipment. They will also be aware of the exposure that they may face. They will be trained to recognize unsafe practices or working conditions that may lead to a fall.

The crew will be trained on the function and operation of safety monitoring systems, guardrails, personal fall protection equipment and control lines.

They will be aware of the construction sequence and the setting plan.

V. Hazards

Because the work deck area is constantly changing as more members are placed, it is not feasible to put up guard rails

until the deck is completed. If everyone was tied off to ropes it will create a tripping hazard causing injury to our employees. This may also hasten their falling off the work deck. The employees assigned to the parking structure will work on this project for the duration of the job. They have been specifically trained to do this type of work and are trained to recognize the fall hazards.

VI. Enforcement

Constant awareness and respect for fall hazards, and compliance with all safety rules are considered conditions of employment. ______________, **Project Superindendent and the Safety Monitor** as well as other safety personnel reserve the right to issue disciplinary warnings to employees up to and including termination for failure to follow the guidelines of this program.

VII. Accident Investigations

All accidents that result in injury to workers, regardless of their nature, shall be investigated and reported. It is an integral part of a safety program that documentation take place as soon as possible so that the cause and means of prevention can be identified to prevent a reoccurrence. In the event that an employee falls or there is some related, serious incident occurring, this plan shall be reviewed to determine if additional practices, procedure, or training need to be implemented to prevent similar types of falls or incidents from occurring.

VIII. Changes to Plan

This plan shall be reviewed as the job progresses to determine if additional practices, procedures or training need to be implemented by ______________ to improve or provide additional fall protection. Workers shall be notified and trained, if necessary, in the new procedures. A copy of this plan and all approved changes shall be maintained at the jobsite.

Appendix D: Data from Construction Manager Interviews and Job Site Investigations

Contents

Table D.1: Construction manager interview database

ID	Type of Business	Type of Residential Work	Type of Construction Manager	Compelled to Comply?	Length of Exposure	PFAS Employed?
1	Corporation	Framing, Siding, GC	Framer	1	4	
2	Corporation	GC, Masonry	Developer/General Contractor	1	1	1
3	Corporation	Roofing Supplier	Other	4	2	1
4	Corporation	Developer, GC, Framing	Developer/General Contractor	2	3	1
5	Corporation	Developer, GC	Developer/General Contractor	2	3	1
6	Corporation	Developer	Developer/General Contractor	2	3	1
7	Corporation	Developer, GC	Developer/General Contractor	5	3	1
8	Corporation	Developer, GC	Developer/General Contractor	1	3	1
9	Corporation	Developer, GC	Developer/General Contractor	4	3	1
10	Corporation	GC	Developer/General Contractor	1	1	1
11	Corporation	Roofing	Roofer	5	5	1
12	Sole proprietorship	Carpenter	Framer	4	3	
13	Public agency	Owner/CM	Owner Representative	1	3	1
14		Architect	Owner Representative	5		1
15		Architect	Owner Representative	5		1
16		Roofing	Roofer	5	5	
17	Corporation	Developer, GC	Developer/General Contractor	2	3	
18	Organization	Roofers Association	Roofer	5		1
19	Corporation	Roofing	Roofer	1	5	1
20	Corporation	Developer, GC	Developer/General Contractor	1	3	1
21	Corporation	Insurance	Other	2		1

Table D.1: (Continued) Construction manager interview database

ID	Guardrails Employed?	Safety Nets Employed?	Monitor System Employed?	Warning Line Employed?	Fall Protection Plan Employed?	Other Systems Employed	No Systems Employed
1			1		1		
2							
3							
4	1		1		1	1	
5							
6			1		1	1	
7			1		1		
8			1		1	1	
9			1		1		
10	1			1	1	1	
11			1	1	1		
12							1
13						1	
14							
15							
16							1
17					1		
18	1		1	1	1	1	
19					1		
20	1					1	
21	1		1	1	1	1	

Table D.1: (Continued) Construction manager interview database

ID	Other Methods	When Fall Protection Plan Is Used	Use Fall Protection Plan for Truss Installation	Use Fall Protection Plan for Sheathing	Use Fall Protection Plan for Roofing	Guardrails Used During Sheathing
1		Truss, Sheathing	1	1		
2						
3		Roof loading			1	
4	"Chicken ladder," U-bolt anchor	Truss	1			1
5						
6	Work platforms	Truss, roofing	1		1	
7		Truss	1			
8	Scaffolds	Truss	1			
9		Truss, sheathing	1	1		
10	"Norris" bucket	Truss	1			1
11		Roofing			1	
12						
13	Scaffolds					
14						
15						
16						
17		Truss, sheathing, roofing	1	1	1	
18						
19		Sheathing		1		
20	Work platforms					
21	"Chicken ladder"	Truss, sheathing	1	1		1

Table D.1: (Continued) Construction manager interview database

ID	Guardrails Used During Roofing	Guardrails Used at Other Times	When Guardrails Used	When Safety Nets Used	PFAS Used During Roofing	PFAS Used During Sheathing	PFAS Used at Other Times
1							
2							1
3					1		
4			Roofing			1	
5					1		
6					1		
7					1		
8					1	1	
9					1		
10	1		Sheathing, roofing		1	1	
11					1		
12							
13					1	1	
14							
15							
16							
17							
18							
19					1		
20		1	Siding		1		
21			Roofing		1	1	

Table D.1: (Continued) Construction manager interview database

ID	When PFAS Used	When is Positive Fall Protection Required	Most Appropriate Method for Truss Installation	Most Appropriate Method for Roof Sheathing	Most Appropriate Method for Roofing, <4:12	Most Appropriate Method for Roofing, 4:12 - 8:12	Most Appropriate Method for Roofing, >8:12
1		2	1	4	0	0	0
2		1	3	3	6	7	3
3	Roof loading	2	0	0	0	0	0
4	Sheathing	1	1	3	0	0	5
5	Roofing	2	0	3	0	3	3
6	Roofing	3	1	1	7	7	3
7	Roofing	4	1	1	1	1	1
8	Sheathing, roofing	1	1	3	3	3	3
9	Roofing	1	1	1	5	5	5
10	Sheathing, roofing	1	2	3	7	5	3
11	Roofing	4	0	0	1	1	3
12		4	0	0	0	0	0
13	Sheathing, roofing	1	2	3	3	3	3
14		4	1	4	4	4	3
15		4	0	0	0	0	0
16		4	0	0	0	0	0
17		3	1	1	0	1	0
18		3	0	0	0	0	0
19	Roofing	2	0	1	3	3	3
20	Roofing	1	2	3	3	3	3
21	Sheathing, roofing	3	1	1	5	5	3

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Table D.1: (Continued) Construction manager interview database

ID	Training Methods	Frequency of Encountering Problems	Economic Problems		Productivity Problems		Subcontractor Behavior Problems		Worker Behavior Problems		Lack of Training Resources Problems	
			Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit
1	Toolbox, Videos, On-site	2	3	1	4	1	5	1	6	1		
2	Toolbox, On-site	5										
3		1	2	1					3	1		
4		3			3	1			2	1		
5		2			3	1	2	1	1	1		
6		2	2	1	1	1			3	1		
7		2	2	1	1	1	3	1				
8	Toolbox, On-site	5										
9	Toolbox	3							2	1		
10	Toolbox, On-site	4					2	1	1	1		
11		2	1	1	2	1			3	1		
12		2	1	1	2	1						
13		4					1	1	2	1		
14		2			1	1			3	1	2	1
15		2	1	1					2	1		
16		1	1	1					2	1		
17		4										
18		1	1	1							4	1
19		3							1	1		
20		4							1	1		
21		2							2	1		

Table D.1: (Continued) Construction manager interview database

ID	Lack of Knowledge Problems		Design Problems		Construction Method Problems		Workers' Compliance Level	Use Because of Personal Reasons		Use Because Requirement of Employment		Use Because Supervisor Enforces		Use Because Peer Pressure	
	Rank	Hit	Rank	Hit	Rank	Hit		Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit
1			1	1	2	1	2	3	1	2	1	1	1	4	1
2							2	3	1	3	1	3	1	5	1
3					1	1	0								
4			1	1			3								
5							4								
6							4								
7					4	1	4								
8							2			2	1	1	1		
9			1	1			3								
10							3			1	1	2	1		
11			4	1			4					1	1		
12					3	1	4								
13			3	1			2			1	1				
14	4	1					5	1	1						
15							5								
16							5								
17			1	1	2	1	2								
18	2	1	3	1			0								
19							2								
20							2			1	1	2	1		
21			1	1			3								

Table D.1: (Continued) Construction manager interview database

ID	Don't Use Because Believe Won't Fall		Don't Use Because Not Requirement of Employment		Don't Use Because Uncomfortable		Don't Use Because Slows Down		Don't Use Because Supervisor Doesn't Enforce		Don't Use Because Peer Pressure		Supervisors' Level of Enforcement	Effects of More Enforcement	
	Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit	Rank	Hit		Likert	Hit
1	1	1			3	1	2	1					2	3	
2	3	1	6	1	3	1	3	1	6	1	6	1	2	2	1
3													0	4	
4	1	1			2	1	3	1					3	0	
5	1	1			2	1	3	1					4	0	
6	3	1			4	1	2	1			1	1	3	4	
7							1	1					4	5	
8													1	0	
9							1	1			2	1	2	0	
10	2	1			1	1	4	1			3	1	2	3	
11	3	1			1	1	2	1					4	3	
12													4	3	
13							1	1	2	1			1	1	1
14	1	1					2	1	4	1	3	1	5	0	
15	1	1									2	1	5	0	
16	2	1			1	1	3	1					5	0	
17					1	1	2	1					2	0	
18													0	2	1
19					1	1							2	0	
20													1	0	
21													0	3	

Table D.1: (Continued) Construction manager interview database

ID	Effects of Increased Training of Workers		Effects of Lower Costs of Equipment		Effects of Cooperation with HIOSH		Effects of Innovative Methods of Protection		Other Ideas for Improvement
	Likert	Hit	Likert	Hit	Likert	Hit	Likert	Hit	
1	2	1	2	1	3		2	1	
2	1	1	1	1	3		2	1	
3	0		2	1	2	1	0		Increased involvement from insurance companies
4	2	1	0		0		2	1	
5	2	1	0		0		0		Union involvement; change culture
6	2	1	0		2	1	0		Prefabrication
7	0		2	1	0		0		More realistic regulations
8	2	1	0		0		0		Increased concern about safety
9	1	1	0		0		2	1	Prefabrication
10	2	1	0		0		2	1	Increased workers' comp; safety msg to children; alternative construction methods
11	3		2	1	3		1	1	
12	3		0		2	1	0		
13	2	1	2	1	0		0		Alternative construction methods
14	0		0		0		0		
15	0		0		0		0		Design for safety
16	0		0		0		0		
17	0		0		0		0		
18	1	1	0		2	1	1	1	Continuing education req'ts
19	0		0		0		1	1	
20	0		0		0		0		Alternative construction methods
21	2	1	0		3		1	1	

Table D-2: Job site inspection database

Site #	Ownership	Number and Type of Units	Type of Construction	Stage of Roof Construction	Type of Roof
2	Private	Multiple condominium units	New construction	Complete	4:12, asphalt shingles
1	Private	Multiple single-family homes	New construction	Sheathing and roofing application	8:12, asphalt shingles
3	Private	Multiple single-family homes	New construction	Framing to roofing application	4:12, asphalt shingles
4	Private	Multiple single-family homes	New construction	Complete	5:12, fiber cement tiles
5	Private	Multiple single-family homes	New construction	Framing and sheathing	5:12, asphalt shingles
6	Private	Multiple single-family homes	New construction	Complete	5:12, asphalt shingles
8	Private	Multiple single-family homes	New construction	Framing to roofing application	4:12, asphalt shingles
9	Private	One single-family home	Renovation	Roofing application (reroofing)	4:12, asphalt shingles
10	Private	One single-family home	Renovation	Complete	6:12, asphalt shingles
11	Private	One single-family home	Renovation	Complete	12:12, asphalt shingles
13	Private	One single-family home	Partial reroofing	Roofing application	4:12, cedar shakes
14	Public	Multiple single-family homes	Renovation	Framing to roofing application	4:12, asphalt shingles
15	Public	Multiple townhouses	Reroofing	Sheathing and roofing application	4:12, asphalt shingles
16	Public	Multiple townhouses	New construction	Framing to roofing application	5:12, asphalt shingles
7	Public	N/A (a)	New construction	Sheathing	4:12, metal
12	Public	N/A (b)	New construction	Roofing application	5:12, asphalt shingles

Notes:

(a) Multiple commercial buildings with residential-style roof (school)
(b) Single commercial building with residential-style roof (childcare center)

Table D-2: (Continued) Job site inspection database

Site #	Level of Compliance	Level of Enforcement	Methods in Use			
			Truss Installation	Sheathing	Roofing Application	Finish
2	4	4	Unknown	PFAS	PFAS	Unknown
1	4	4	Plan	PFAS	Guardrail	U-bolt
3	4	2	Plan	Plan	Plan	Sawhorse "scaffolds"
4	4	4	Plan	Plan	PFAS	Unknown
5	2	1	Plan	PFAS	PFAS	Scaffolds
6	4	4	Plan	Plan	PFAS	None
8	3	2	Plan	Plan	PFAS	Unknown
9	5	5	N/A	N/A	None	None
10	5	5	None	None	None	None
11	5	5	None	None	None	None
13	5	5	N/A	N/A	None	N/A
14	4	4	Plan	Plan	Plan	None
15	2	2	N/A	Plan	PFAS	N/A
16	2	2	Scaffolds	PFAS	PFAS	Guardrail
7	3	2	Plan	Warning line	Guardrail	Unknown
12	3	4	Scaffolds	PFAS	PFAS	PFAS

Table D-2: (Continued) Job site inspection database

	Methods in Use					
Site #	PFAS	Plan	Guardrail	Warning line	Other	None
2	1					
1	1	1	1		1	
3		1			1	
4	1	1				
5	1	1			1	
6	1	1				
8	1	1				
9						1
10						1
11						1
13						1
14		1				
15	1	1				
16	1		1		1	
7		1	1	1		
12	1				1	

Appendix E: Worker Survey and Data

Contents:

Exhibit E.1: Worker Survey

Investigation of Fall Protection for Residential Construction

WORKER SURVEY

The following survey deals with fall protection for residential construction. We ask for your voluntary participation in this survey, which was designed to gain information about your views on OSHA fall protection regulations in residential construction. The new regulations have been in effect since February 1995, and research is being undertaken at the University of Hawaii to formulate alternative—perhaps improved—methods of protecting residential construction workers from falls. This research is supported by the Hawaii Department of Labor and Industrial Relations, Division of Occupational Safety and Health, and by the United States Department of the Navy.

The current regulations for fall protection for residential construction are found in the Code of Federal Regulations, 29 CFR Part 1926, Subpart M (1926.500 to 1926.503), and in the State of Hawaii Administrative Rules, 12-121.2. For your information and assistance in completing this survey, highlights of the new standards are attached.

Your participation in this survey is fully voluntary. The information you provide will be kept strictly confidential, and you may withdraw this information at any time by calling the researchers at 956-3933. Please feel free to call them at any time if you have any questions regarding this survey or the implementation of fall protection in residential construction. Please return your completed questionnaire to the union office, where it will be collected for the researchers.

INFORMATION ABOUT YOURSELF:

1. How long have you worked in the construction industry? ___ years, ___ months

2. Are you a:

____ Roofer
____ Carpenter
____ Other (Please specify: ______________________.)

3. Are you a union member? YES NO (Circle one.)

4. Are you a: JOURNEYMAN APPRENTICE (Circle one.)

5. Are you: MARRIED SINGLE/DIVORCED/WIDOWED (Circle one.)

6. Do you have children? YES NO (Circle one.)
(If so, how old is your youngest child? _____ years)

7. How many residential projects have you completed or worked on during the past year? (Include those currently in progress.) _______

8. How many of those projects, if any, have been constructed for the military? ______

9. How many of those projects were:

____ New construction
____ Renovation/addition
____ Maintenance (e.g., reroofing)

Exhibit E.1: (Continued) Worker Survey

10. What is the average size of the residential projects on which you are working? _____ unit(s)

11. How long are you exposed to fall hazards during your typical workday?
< 15 MIN   15 MIN - 1 HR   1-2 HRS   2-4 HRS   > 4 HRS   (Circle one.)

ACCIDENT HISTORY:

1. In the past three years, while working on residential construction/maintenance projects, how many accidents have you had? _______

2. How many more have you witnessed? ________

3. Of those accidents, how many involved falls from heights of 6 ft or more? ___

4. How many of those accidents resulted in the following:
   - Death _______
   - Paralysis or loss of limb/eye _______
   - Fracture _______
   - Other injury (e.g., sprain, etc.) _______
   - No injury _______

YOUR EMPLOYER'S SAFETY PROGRAM:

1. Does your employer have a written safety program in effect?
   YES   NO   I DON'T KNOW   (Circle one.)

2. Does your employer have a written fall protection program in effect?
   YES   NO   I DON'T KNOW   (Circle one.)

3. How many employees work for your company?
____ 1-10 ____ 11-20 ____ 21-50 ____ 51-100 ____ 101-500 ____ Over 500

4. Recognizing that different employers assign safety responsibilities in differing ways, who is assigned these responsibilities at your company? (Check just one.)

____ President	____ Project Manager
____ Vice President	____ Project Engineer
____ Safety Manager	____ Superintendent/General Foreman/Foreman
____ Safety Administrator	____ I don't know.

5. Which methods of fall protection does your employer use on residential construction? (Please check all that apply.)
____ Personal fall arrest system (safety harness, lanyard, & anchorage system)
____ Guardrails
____ Safety nets
____ Controlled access zones (only trained, competent workers allowed in the fall hazard area)
____ Safety monitoring systems (one employee acts as a safety observer)
____ Warning line systems
____ Fall protection plans
____ Other (Please list any other alternative methods used: ________________________
____.)

6. During which specific instances does your firm use non-conventional fall protection methods, such as controlled access zones, safety monitoring systems, warning line systems, fall protection plans, and/or other alternative methods? (Please check all applicable.)

___ Truss installation
___ Roof sheathing
___ Roofing/reroofing (If so, what is the steepest slope on which you use non-conventional methods of fall protection? ___ in 12.)
___ Other (Please specify all other instances in which non-conventional methods of fall protection are utilized: ____ ____.)

7. During which specific instances does your firm use guardrails? (Please check all that apply.)

___ Truss installation
___ Roof sheathing
___ Roofing/reroofing (If so, what is the lowest slope on which you use guardrails? ___ in 12. And the steepest slope on which you use guardrails? ___ in 12.)
___ Other (Please specify: ____.)

8. During which specific instances does your firm use safety nets? (Please check all that apply.)

___ Truss installation
___ Roof sheathing
___ Roofing/reroofing (If so, what is the lowest slope on which you use safety nets? ___ in 12. And the steepest slope on which you use safety nets? ___ in 12.)
___ Other (Please specify: ____.)

9. During which specific instances does your firm use personal fall arrest systems (PFAS)? (Please check all that apply.)

___ Truss installation
___ Roof sheathing
___ Roofing/reroofing (If so, what is the lowest slope on which you use PFAS? ___ in 12. And the steepest slope on which you use PFAS? ___ in 12.)
___ Other (Please specify: ____.)

10. How does your employer train you on fall protection methods? (Please check all that apply.)

____ "Toolbox" or stand-up meetings, by supervisor
____ Videos
____ On-site training by competent person
____ Off-site training by competent person
____ No training on fall protection

YOUR OPINIONS ON FALL PROTECTION:

1. During the time when you are exposed to fall hazards, how often do you use some positive form of fall protection (such as a safety harness, guardrails, or safety nets)?

ALWAYS FREQUENTLY SOMETIMES SELDOM NEVER

(Circle one.)

Exhibit E.1: (Continued) Worker Survey

2. If working on a roof not more than 20 feet above the ground at the eaves, at what slope do you feel positive fall protection systems (i.e., personal fall arrest system, guardrail, or safety net) is required?

ALWAYS REQUIRED	AT SLOPES STEEPER THAN 4 in 12	AT SLOPES ABOVE 4 in 12 BUT BELOW 8 in 12	AT SLOPES OF 8 in 12 OR STEEPER	NEVER REQUIRED

(Circle one.)

3. Does the surface of the roof (i.e., clay tile, asphalt shingles, plywood sheathing only) make a difference as to what type of fall protection you would choose? YES NO (Circle one.)

4. Please rank the following common roofing surfaces from most dangerous (1) to least dangerous (7):

____No sheathing; sheathing installation in progress
____Sheathing complete; plywood decking
____Paper complete; paper roof
____Asphalt shingle roof
____Cedar shake roof
____Clay tile roof
____Metal roof

5. Which of the following forms of fall protection do you prefer in the following roof construction applications? (Please choose only one form of fall protection for each application listed.)

Application	Personal fall arrest sytem	Guard-rail	Safety net	Con-trolled access zones	Safety monitor system	Warning line system	Fall protec-tion plan	Work from scaffolds /ladders	Slide guards	None
Truss installation										
Roof sheathing										
Roofing, slope 4:12 or less										
Roofing, slope between 4:12 and 8:12										
Roofing, slope 8:12 or more										

6. How often do you encounter problems which make it difficult for you to utilize fall protection?

ALWAYS FREQUENTLY SOMETIMES SELDOM NEVER

(Circle one.)

Exhibit E.1: (Continued) Worker Survey

7. How would you characterize these problems? (Please rank the following common problems from most frequent (1) to least frequent (6).)

____ No suitable anchorage point
____ Inadequate fall protection equipment available
____ Takes too much time away from production to comply with the regulations
____ Inadequate training—don't know how to use fall protection equipment properly
____ Creates a greater hazard (slip/trip hazard) to use fall protection
____ Other (Please specify: ____.)

8. Why would you use fall protection? (Please rank the following common reasons from most frequent (1) to least frequent (5).)

____ Personal security and safety
____ Requirement of employer
____ Supervisor enforcement
____ Pressure from fellow safety-conscious workers
____ Other (Please specify: ____.)

9. Why would you not use fall protection? (Please rank the following common reasons from most frequent (1) to least frequent (7).)

____ Don't believe that you will fall
____ Not a mandatory requirement of your employer
____ Uncomfortable
____ Slows you down; affects your productivity
____ Not enforced by supervision
____ Pressure from fellow workers to not use fall protection
____ Other (Please specify: ____.)

10. How often does your employer enforce the use of fall protection?

ALWAYS FREQUENTLY SOMETIMES SELDOM NEVER

(Circle one.)

11. How would you characterize your own level of compliance with regards to using fall protection?

ALWAYS COMPLY | COMPLY MOST OF THE TIME | SOMETIMES COMPLY | SELDOM COMPLY | NEVER COMPLY

(Circle one.)

12. Do you feel that the following actions would encourage or discourage the use of fall protection?

a. Harsher regulations/more enforcement and inspection

STRONGLY ENCOURAGE ITS USE | SOMEWHAT ENCOURAGE ITS USE | NEITHER ENCOURAGE NOR DISCOURAGE ITS USE | SOMEWHAT DISCOURAGE ITS USE | STRONGLY DISCOURAGE ITS USE

(Circle one.)

Exhibit E.1: (Continued) Worker Survey

b. More training for yourself and your fellow workers in proper fall protection methods

STRONGLY ENCOURAGE ITS USE	SOMEWHAT ENCOURAGE ITS USE	NEITHER ENCOURAGE NOR DISCOURAGE ITS USE	SOMEWHAT DISCOURAGE ITS USE	STRONGLY DISCOURAGE ITS USE

(Circle one.)

c. Lower cost of fall protection equipment

STRONGLY ENCOURAGE ITS USE	SOMEWHAT ENCOURAGE ITS USE	NEITHER ENCOURAGE NOR DISCOURAGE ITS USE	SOMEWHAT DISCOURAGE ITS USE	STRONGLY DISCOURAGE ITS USE

(Circle one.)

d. More cooperation with HIOSH and OSHA in training/consultation with your employer

STRONGLY ENCOURAGE ITS USE	SOMEWHAT ENCOURAGE ITS USE	NEITHER ENCOURAGE NOR DISCOURAGE ITS USE	SOMEWHAT DISCOURAGE ITS USE	STRONGLY DISCOURAGE ITS USE

(Circle one.)

e. More innovative methods of fall protection (less restrictive, etc.)

STRONGLY ENCOURAGE ITS USE	SOMEWHAT ENCOURAGE ITS USE	NEITHER ENCOURAGE NOR DISCOURAGE ITS USE	SOMEWHAT DISCOURAGE ITS USE	STRONGLY DISCOURAGE ITS USE

(Circle one.)

13. How, in your opinion, could the current fall protection regulations be improved?

____

____

____

Thank you very much for your time and assistance. Is there any other information which you would like to share concerning your position on the new OSHA fall protection regulations?

____

____

____

Please return this survey to the union office, where it will be collected in a secure location awaiting pick-up by the researchers. Again, if the researchers can be of any help to you regarding the implementation of fall protection for residential construction, please call 956-3933.

Table E.1: Worker survey database

ID	Construction Experience	Trade	Collective Bargaining	Journeyman/ Apprentice	Marital Status	Children?	Age of Youngest	Length of Exposure	Self Accidents	Witnessed Accidents	Falls Witnessed
1	2	Carpenter	Union	Apprentice	Single	FALSE		1	0	1	0
2	15	Carpenter	Union	Journeyman	Single	FALSE		4	0	1	0
3	1	Carpenter	Union	Apprentice	Single	TRUE	2	1	0	0	0
4	2	Carpenter	Union	Apprentice	Single	TRUE		5	1		1
5	4	Carpenter	Union	Apprentice	Single	FALSE		3	1	2	0
6	2	Carpenter	Union	Apprentice	Single	FALSE		1	1		0
7	10	Carpenter	Union	Apprentice	Married	TRUE	21	3	1	0	0
8	3	Carpenter	Union	Apprentice	Single	FALSE		2	1	0	0
9	6	Carpenter	Union	Apprentice	Single	TRUE	2	1	0	4	0
10	5	Carpenter	Union	Apprentice	Single	FALSE		1	0	1	1
11	2	Carpenter	Union	Apprentice				3			
12	2	Carpenter	Union	Apprentice	Married	FALSE		5	1	2	2
13	2	Carpenter	Union	Apprentice	Single	FALSE		0	0	0	0
14	3	Roofer	Union	Apprentice	Single	TRUE	3	5	0	0	0
15	0	Roofer	Union	Apprentice	Single	FALSE		5	0	0	0
16	2	Roofer	Union	Apprentice	Married	TRUE	1	3	1	1	2
17	1	Roofer	Union	Apprentice	Single	TRUE	1	4	2	4	0
18	5	Roofer	Union	Apprentice	Single	TRUE	1	2	1	0	0
19	2	Roofer	Union	Apprentice	Married	FALSE		2	1	0	0
20		Roofer	Union	Apprentice	Single	TRUE	1	3	1	0	0
21		Roofer	Union	Apprentice	Married	TRUE	11	2	0	3	0
22	7	Roofer	Union	Apprentice	Married	FALSE		2	1	2	0
23	1	Roofer	Union	Apprentice	Single	FALSE		5	0	1	1

Table E.1: (Continued) Worker survey database

ID	Disabilities Witnessed	Fractures Witnessed	Other Injuries Witnessed	Accidents w/o Injury Witnessed	Methods Used	PFAS Employed?	Guardrails Employed?	Safety Nets Employed?	Monitor System Employed?
1	0	0	1	0	PFAS, Guardrail, Plan	1	1		
2	0	0	1	0	CAZ, Monitor				1
3	0	0	0	0	PFAS, CAZ	1			
4	0	0	0	1	PFAS, Guardrails	1	1		
5	0	1	2	0	CAZ, Plan				
6					PFAS, Guardrails	1	1		
7					*ALL*	1	1	1	1
8	0	0	1	0	Guardrails		1		1
9	0	0	4	0	PFAS, Guardrails, CAZ, Plan	1	1		
10	0	1	0	0	PFAS	1			
11					Warn Line				
12					CAZ				
13	0	0	0	0	PFAS, Guardrail, Monitor, Plan, Hard Hat	1	1		1
14	0	0	0	0	PFAS	1			
15	0	0	0	0	PFAS, Plan	1			
16	0	0	0	2	PFAS, Guardrails	1	1		
17	1		1	0	PFAS, CAZ, Plan	1			
18				1					
19	0	0	1	0	PFAS	1			
20	0	0	1	0					
21									
22			3		PFAS	1			
23	0	0	1	0	PFAS, Guardrail	1	1		

Table E.1: (Continued) Worker survey database

ID	Warning Line Employed?	Fall Protection Plan Employed?	No Answer	When Fall Protection Plan Is Used	Use Fall Protection Plan for Truss Installation	Use Fall Protection Plan for Sheathing	Use Fall Protection Plan for Roofing	Not Used	No Answer
1		1		Sheathing		1			
2		1		Truss, Sheathing	1	1			
3		1							1
4				Roofing			1		
5		1		Sheathing		1			
6				Truss, Sheathing, Roofing	1	1	1		
7	1	1		Truss	1				
8		1		Truss	1				
9		1							1
10				Sheathing		1			
11	1			Truss, Sheathing	1	1			
12		1		Truss, Sheathing, Roofing	1	1	1		
13		1		Truss, Sheathing	1	1			
14				Truss	1				
15		1		Roofing (1:12)			1		
16									1
17		1		Roofing			1		
18			1	Not Used				1	
19									1
20			1						1
21			1	Truss	1				
22				Sheathing		1			
23									1

Table E.1: (Continued) Worker survey database

ID	When Guardrails Used	Guardrails Used During Truss Installation	Guardrails Used During Sheathing	Guardrails Used During Roofing	Guardrails Used at Other Times	Not Used	No Answer	When PFAS Used
1							1	Not Used
2	Not Used					1		Sheathing
3							1	Sheathing
4	Sheathing		1					Not Used
5	Not Used					1		Truss, Sheathing, Roofing
6	Truss, Sheathing, Roofing	1	1	1				Truss, Sheathing, Roofing
7	Truss, Sheathing, Roofing	1	1	1				
8	Truss	1						Sheathing
9	Sheathing		1					
10							1	
11							1	
12							1	Truss, Sheathing
13	Subfloor				1			Not Used
14	Truss	1						Roofing (3:12 -12:12)
15	Roofing (0:12 - 2:12)			1				
16	Roofing (2:12 - 3:12)			1				
17							1	Not Used
18	Not Used					1		
19	Sheathing		1					
20							1	Sheathing
21	Roofing			1				
22							1	Roofing (5:12-8:12)
23	Roofing (1:12-1:12)			1				

Table E.1: (Continued) Worker survey database

ID	PFAS Used During Truss Installation	PFAS Used During Sheathing	PFAS Used During Roofing	Not Used	No Answer	Method of Training	Personal Use of Positive Protection	When is Positive Fall Protection Required	Surface Affect Method?	Danger of Rafters	
										Rank	Pts
1				1		Toolbox, On-site	1	1	TRUE		
2		1				No Training	5	3	TRUE	2	5
3		1				Off-site	3		FALSE		
4				1		On-site	2	1	FALSE	1	6
5	1	1	1			Toolbox, On-site					
6	1	1	1			On-site	1	1	TRUE		
7					1	All	3	2	TRUE		
8		1					4	4	TRUE	2	5
9					1	Toolbox, Videos	3	3	TRUE	3	4
10					1	Toolbox	5	4	TRUE	2	5
11					1		5	5			
12	1	1			1	No Training	5	3	TRUE	6	1
13				1		Toolbox, On-site	1	1	FALSE	1	6
14			1			Videos, On-site	3	4	FALSE	4	3
15					1	Toolbox, Videos, On-site, Off-	1	1	TRUE	1	6
16					1	No Training	3	2	FALSE	2	5
17				1		Toolbox, Videos, On-site, Off-	2		TRUE		
18					1	No Training	4	3		1	6
19					1	Toolbox, Videos, On-site	1	2	TRUE	1	6
20		1					5		FALSE	7	0
21					1	Off-site	2	1	TRUE		
22			1			Toolbox	1	1		2	5
23					1	Toolbox	2	2	TRUE	3	4

Table E.1: (Continued) Worker survey database

ID	Danger of Sheathing		Danger of Paper		Danger of Asphalt Shingles		Danger of Cedar Shakes		Danger of Clay Tile		Danger of Metal		Most Appropriate Method for Truss Installation		Most Appropriate Method for Roof Sheathing	
	Rank	Pts	Rank	Pts	Rank	Pts	Rank	Pts	Rank	Pts	Rank	Pts				
1																
2	3	4	7	0	6	1	5	2	5	2	1	6	Guardrail		Plan	
3																
4	2	5	3	4	4	3	5	2	6	1	7	0				
5																
6	1	6														
7																
8	6	1	7	0	5	2	4	3	3	4	1	6	None		None	
9	4	3	7	0	6	1	5	2	1	6	2	5				
10	4	3	1	6	7	0	6	1	3	4	5	2	PFAS		Net	
11																
12	7	0	4	3	5	2	2	5	3	4	1	6	Plan		Net	Plan
13	2	5	7	0	5	2	6	1	4	3	3	4	PFAS	Plan	PFAS	Plan
14	5	2	6	1	7	0	3	4	2	5	1	6	Plan		Plan	
15	5	2	2	5	6	1	7	0	3	4	4	3	PFAS		PFAS	
16	3	4	4	3	7	0	5	2	6	1	1	6	PFAS		PFAS	
17																
18	7	0	7	0	7	0	7	0	7	0	7	0	None		None	
19	2	5	7	0	6	1	4	3	3	4	5	2				
20	7	0	7	0	7	0	7	0	2	5	2	5				
21	1	6														
22	7	0	5	2	7	0	2	5	4	3	4	3				
23	4	3	7	0	6	1	5	2	2	5	1	6	PFAS	Scaffold		

Table E.1: (Continued) Worker survey database

ID	Most Appropriate Method for Roofing, <4:12		Most Appropriate Method for Roofing, 4:12 - 8:12		Most Appropriate Method for Roofing, >8:12		Frequency of Encountering Problems	Problem with Suitable Anchorage			Problem with Equipment Available		
								Rank	Pts	Hit	Rank	Pts	Hit
1							3	1	5	1	2	4	1
2			Guardrail		Guardrail		3	5	1	1	2	4	1
3							3						
4							4						
5													
6													
7								3	3	1	3	3	1
8	None		Guardrail		PFAS		4	5	1	1	4	2	1
9							3						
10	Guardrail		Monitor		Plan		2	4	2	1	3	3	1
11													
12	Plan		PFAS	Plan	PFAS	Plan	3	2	4	1	5	1	1
13	PFAS	Plan	PFAS	Plan	PFAS	Plan	2	3	3	1	4	2	1
14	Plan		Plan		Plan		4	3	3	1	2	4	1
15	Guardrail		PFAS		PFAS		2	5	1	1	3	3	1
16	PFAS		PFAS		Slide Guards		2	4	2	1	3	3	1
17							3	5	1	1	5	1	1
18	None		None		None		5						
19							2	3	3	1	2	4	1
20													
21							3	1	5	1			
22													
23	Guardrail		PFAS		PFAS	Scaffold	2	3	3	1	4	2	1

Table E.1: (Continued) Worker survey database

ID	Problem with Time			Problem with Training			Problem with Greater Hazard			Use Because of Personal Reasons			Use Because Requirement of Employment			Use Because Supervisor Enforces		
	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit
1	3	3	1	4	2	1	5	1	1	1	5	1	2	4	1	3	3	1
2	1	5	1	3	3	1	4	2	1									
3																		
4																		
5																		
6	1	5	1													1	5	1
7				3	3	1				3	3	1				3	3	1
8	2	4	1	1	5	1	5	1	1	1	5	1	4	2	1	3	3	1
9																		
10	2	4	1	5	1	1	1	5	1	2	4	1	3	3	1	1	5	1
11																		
12	1	5	1	4	2	1	3	3	1	1	5	1	2	4	1	3	3	1
13	2	4	1	5	1	1	1	5	1	1	5	1	2	4	1	3	3	1
14	4	2	1	1	5	1	5	1	1	3	3	1	1	5	1	2	4	1
15	1	5	1	2	4	1	4	2	1	1	5	1	3	3	1	4	2	1
16	2	4	1	5	1	1	1	5	1	2	4	1	1	5	1	3	3	1
17	1	5	1	5	1	1	5	1	1	3	3	1	3	3	1	3	3	1
18										3	3	1	3	3	1	3	3	1
19	4	2	1	5	1	1	1	5	1	4	2	1	1	5	1	2	4	1
20																		
21													1	5	1			
22																		
23	1	5	1	5	1	1	2	4	1	1	5	1	2	4	1	3	3	1

Table E.1: (Continued) Worker survey database

ID	Use Because Peer Pressure			Don't Use Because Believe Won't Fall			Don't Use Because Not Requirement of Employment			Don't Use Because Uncomfortable			Don't Use Because Slows Down			Don't Use Because Supervisor Doesn't Enforce		
	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit	Rank	Pts	Hit
1	4	2	1	6	0	1	5	1	1	4	2	1	3	3	1	2	4	1
2																		
3																		
4																		
5																		
6										1	5	1						
7	3	3	1				5	1	1	5	1	1	5	1	1	2	4	1
8	2	4	1	4	2	1	5	1	1	1	5	1	2	4	1	3	3	1
9																		
10	4	2	1	3	3	1	2	4	1	4	2	1	1	5	1	5	1	1
11																		
12	4	2	1	3	3	1	4	2	1	1	5	1	2	4	1	6	0	1
13	4	2	1	3	3	1	4	2	1	2	4	1	1	5	1	6	0	1
14	4	2	1	4	2	1	5	1	1	1	5	1	2	4	1	6	0	1
15	2	4	1	2	4	1	3	3	1	4	2	1	1	5	1	5	1	1
16	4	2	1	5	1	1	2	4	1	3	3	1	1	5	1	4	2	1
17	4	2	1	6	0	1	6	0	1	3	3	1	1	5	1	6	0	1
18	5	1	1	6	0	1	2	4	1	4	2	1	3	3	1	2	4	1
19	3	3	1	6	0	1	5	1	1	2	4	1	1	5	1	4	2	1
20																		
21				1	5	1												
22																		
23	4	2	1	6	0	1	4	2	1	3	3	1	1	5	1	2	4	1

Table E.1: (Continued) Worker survey database

ID	Don't Use Because Peer Pressure			Supervisors' Level of Enforcement	Self Compliance Level	Effects of More Enforcement		Effects of Increased Training of Workers		Effects of Lower Costs of Equipment		Effects of Cooperation with HIOSH		Effects of Innovative Methods of Protection	
	Rank	Pts	Hit			Rank	Pts	Rank	Pts	Rank	Pts	Rank	Pts	Rank	Pts
1	1	5	1	1	2	1	2	1	2	1	2	1	2	1	2
2															
3				2	3	3	0	2	1	3	0	2	1	2	1
4															
5															
6				2	2	1	2	3	0	2	1	3	0	2	1
7	2	4	1												
8	6	0	1	4	4	4	-1	3	0	3	0	3	0	3	0
9															
10	6	0	1	5	2	3	0	4	-1	1	2	3	0	5	-2
11															
12	5	1	1	1	2	2	1	2	1	1	2	2	1	2	1
13	5	1	1	2	2	4	-1	2	1	1	2	2	1	1	2
14	3	3	1	4	3	2	1	2	1	3	0	3	0	3	0
15	6	0	1	2	1	1	2	2	1	1	2	1	2	2	1
16	6	0	1	1	2	1	2	3	0	3	0	2	1	3	0
17	2	4	1	2	2	1	2	1	2	2	1	2	1	2	1
18	6	0	1	5	1	2	1	3	0	3	0	3	0	3	0
19	3	3	1	1	1	1	2	2	1	2	1	2	1	2	1
20				5	4	4	-1	3	0	4	-1	4	-1	4	-1
21				2	2	3	0	2	1	3	0	4	-1	3	0
22				1	1	1	2	2	1	2	1	1	2	2	1
23	5	1	1	2	2	2	1	2	1	1	2	2	1	1	2

Appendix F: Data from Case Histories

Table F-1: Case history database

Case #	Ownership	Number and Type of Units	Type of Construction	Stage of Roof Construction	Collective Bargaining
1	Private	One single-family home	New construction	Truss installation	Non-union
2	Private	Multiple single-family homes	New construction	Truss installation	Union
3	Private	One single-family home	New construction	Framing (wall sections)	Non-union
4	Private	One single-family home	New construction	Truss installation	Non-union
5	Private	Multiple single-family homes	New construction	Sheathing	Non-union
6	Private	One single-family home	Renovation	Truss installation	Non-union
7	Private	One single-family home	New construction	Truss installation	Union
8	Public	Multiple condominium units	New construction	Roofing application	Union

Table F-1: (Continued) Case history database

Case #	Citation(s)	Classification of Citation	Proposed Penalty	Abated Penalty
1	Walking top plate	Serious	$525	$315
2	Walking top plate	Serious	$2,975	$1,488
	Insufficient training	Serious	$2,975	$1,488
	No record of training	General	$0	$0
3	Walking top plate, working on 11" plank, open-sided floors	Serious	$1,050	unknown
4	Walking top plate	Serious	$525	$525
	No training program	Serious	$0	$0
	No record of training	General	$0	$0
5	Nailing sheathing	Serious	$2,500	$1,500
	No training program	Serious	$2,500	$1,500
	No record of training	General	$0	$0
6	Walking top plate	Serious	$525	$525
	No training program	Other	$0	$0
	No record of training	Other	$0	$0
7	Walking top plate; fascia installation	Serious	$900	$450
	No training program	Other	$0	$0
	No record of training	Other	$0	$0
8	No record of training	Other	$0	$0

Appendix G: Fall Protection System Analysis Forms

Contents

Exhibit G.1: Guardrail System Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
4 man-hours

Materials
16 stanchions
36 2" x 6" planks
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
guardrail installation/ maintenance = 2 hrs

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $70
material = $650.04
equipment = $0
training = $60
total = $780.04

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 0.92 (Mean)

WORKER INVOLVEMENT

Self-monitoring at gabled edges

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Passive, positive protection from falls to lower level from rake edges
No protection from falls through roof nor from falls to lower level from gabled edges

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.2: PFAS Variant 1 (Roof Truss Anchor) Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
1 man-hour

Materials
2 full-body harnesses
2 3 ft rope lanyards
2 rope grabs
2 nylon rope lifelines (15 ft ea)
2 roof truss anchors
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
PFAS = 2 hrs
situational use = 1 hr

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $17.50
material = $281.40
equipment = $0
training = $120
total = $418.90

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 1.25 (Mean)

WORKER INVOLVEMENT

Attachment of lanyard to lifeline
Adjustment of rope grab as required by movement

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Active, positive protection from falls to lower level from all edges
Active, positive protection from falls through roof

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.3: PFAS Variant 2 (Safe-T-Strap™) Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
1 man-hour

Materials
2 full-body harnesses
2 3 ft rope lanyards
2 rope grabs
2 nylon rope lifelines (15 ft ea)
2 Safe-T-Straps™
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
PFAS = 2 hrs
situational use = 1 hr

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $17.50
material = $251.40
equipment = $0
training = $120
total = $388.90

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 1.25 (Mean)

WORKER INVOLVEMENT

Attachment of lanyard to lifeline
Adjustment of rope grab as required by movement

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Active, positive protection from falls to lower level from all edges
Active, positive protection from falls through roof

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.4: Combination Warning Line/Lifeline System Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
1 man-hour

Materials
2 full-body harnesses
2 3 ft rope lanyards
2 nylon rope lifelines (45 ft ea)
4 nylon rope lifelines (12 ft ea)
10 roof anchors
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
warning line = 1 hr
PFAS = 2 hrs

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $17.50
material = $402.32
equipment = $0
training = $120
total = $539.82

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: -0.50 (Mean)

WORKER INVOLVEMENT

Attachment of lanyard to lifeline when below line, and switching to next line segment as required by movement

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Active, positive protection from falls to lower level from all edges, when below line
No positive protection above line, except for warning line

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.5: Fall Protection Plan Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
8 man-hours
(overhead staff)

Materials
none

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
fall protection course = 24 hrs

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $150.00
training = $720.00
total = $870.00

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 2.00 (Mean)

WORKER INVOLVEMENT

Dependent upon plan

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Dependent upon plan

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.6: Roof Jack System Analysis, Condition 1 (Roof Jacks Alone)

RESOURCES REQUIRED TO IMPLEMENT

Labor
4 man-hours

Materials
12 brackets
12 2" x 6" planks
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
roof jacks = 1 hr
PFAS = 2 hrs
situational use = 1 hr

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $70.00
material = $148.68
equipment = $0
training = $180.00
total = $398.68

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 0.64 (Mean)

WORKER INVOLVEMENT

Self-monitoring at gabled edges and when below jacks

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

No protection from falls through roof nor from falls off gabled edges
Some protection from falls off rake edges; jacks should stop slide of persons
No protection below jacks to falls off rake edges

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.7: Roof Jack System Analysis, Condition 2 (Jacks Plus Positioning Device)

RESOURCES REQUIRED TO IMPLEMENT

Labor
4 man-hours

Materials
Roof jacks:
12 brackets
12 2" x 6" planks
nails

Positioning device:
2 harnesses
2 retractable lanyards
2 roof anchors
nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
roof jacks = 1 hr
PFAS = 2 hrs
situational use = 1 hr

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $70.00
material = $2001.28
equipment = $0
training = $180.00
total = $2251.28

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <6:12	-2	-1	0	1	2
Roofing, slope 6:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 1.00 (Mean)

WORKER INVOLVEMENT

None

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Passive, positive protection afforded from all fall hazards

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.8: Roof Jack System Analysis, Condition 3 (PFAS)

RESOURCES REQUIRED TO IMPLEMENT

Labor	Materials
4 man-hours	2 harnesses 2 3 ft rope lanyards 2 rope grabs 2 nylon rope lifelines (15 ft each) 2 roof anchors nails

Equipment
none

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
roof jacks = 1 hr
PFAS = 2 hrs
situational use = 1 hr

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $70.00
material = $272.00
equipment = $0
training = $180.00
total = $522.00

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <6:12	-2	-1	0	1	2
Roofing, slope 6:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: 0.91 (Mean)

WORKER INVOLVEMENT

Attachment of lanyard to lifeline
Adjustment of rope grab as required by movement

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Active, positive protection afforded from all fall hazards

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.9: Scaffolding and Work Platforms Analysis

RESOURCES REQUIRED TO IMPLEMENT

Labor
6 man-hours

Materials
17 pairs of sawhorses
34 2" x 12" planks

Equipment
30 ft long x 14 ft high scaffold

	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE
Degree of Feasibility:	-2	-1	0	1	2

Training
scaffold erection = 8 hrs

	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE
Degree of Simplicity:	-2	-1	0	1	2

Costs
labor = $105
material = $517
equipment = $190
training = $125
total = $937

	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL
Degree of Economy:	-2	-1	0	1	2

APPLICABILITY

	NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
Truss Installation	-2	-1	0	1	2
Sheathing	-2	-1	0	1	2
Roofing, slope <4:12	-2	-1	0	1	2
Roofing, slope 4:12-8:12	-2	-1	0	1	2
Roofing, slope > 8:12	-2	-1	0	1	2
Roofing, hip	-2	-1	0	1	2
Roofing, gable	-2	-1	0	1	2
Roofing, asphalt	-2	-1	0	1	2
Roofing, cedar	-2	-1	0	1	2
Roofing, clay	-2	-1	0	1	2
Roofing, metal	-2	-1	0	1	2
Finish work	-2	-1	0	1	2

Degree of Flexibility: -0.83 (Mean)

WORKER INVOLVEMENT

None following installation

	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT
Degree of Passivity:	-2	-1	0	1	2

WORKER PROTECTION

Passive, positive protection from all fall hazards during truss installation

	VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Protection:	-2	-1	0	1	2

Exhibit G.10: Prefabrication Analysis

RESOURCES REQUIRED TO IMPLEMENT						APPLICABILITY					
Labor: 4 man-hours; Materials: none							NOT AT ALL APPLICABLE	APPLICABLE IF MODIFIED	SOMEWHAT APPLICABLE	MOSTLY APPLICABLE	HIGHLY APPLICABLE
						Truss Installation	-2	-1	0	1	2
						Sheathing	-2	-1	0	1	2
Equipment: 15-ton crane						Roofing, slope <4:12	-2	-1	0	1	2
						Roofing, slope 4:12-8:12	-2	-1	0	1	2
	HIGHLY INFEASIBLE	SOMEWHAT INFEASIBLE	SLIGHTLY FEASIBLE	SOMEWHAT FEASIBLE	HIGHLY FEASIBLE	Roofing, slope > 8:12	-2	-1	0	1	2
Degree of Feasibility:	-2	-1	0	1	2	Roofing, hip	-2	-1	0	1	2
Training: crane safety awareness = 2 hrs	HIGHLY COMPLEX	SOMEWHAT COMPLEX	SLIGHTLY COMPLEX	SOMEWHAT SIMPLE	VERY SIMPLE	Roofing, gable	-2	-1	0	1	2
Degree of Simplicity:	-2	-1	0	1	2	Roofing, asphalt	-2	-1	0	1	2
Costs: labor = $70; material = $0; equipment = $400; training = $120; productivity credit = -$280; total = $310	NOT AT ALL ECONOMICAL	SOMEWHAT UNECONOMICAL	SLIGHTLY UNECONOMICAL	SOMEWHAT ECONOMICAL	HIGHLY ECONOMICAL	Roofing, cedar	-2	-1	0	1	2
						Roofing, clay	-2	-1	0	1	2
						Roofing, metal	-2	-1	0	1	2
						Finish work	-2	-1	0	1	2
Degree of Economy:	-2	-1	0	1	2	Degree of Flexibility: 0.50 (Mean)					

WORKER INVOLVEMENT						WORKER PROTECTION					
None						Passive, positive protection from all fall hazards during prefabrication. Must utilize some form of fall protection during installation					
	REQUIRES EXTENSIVE WORKER INVOLVEMENT	REQUIRES FREQUENT INVOLVEMENT	REQUIRES SOME INVOLVEMENT	REQUIRES LOW INVOLVEMENT	REQUIRES NO INVOLVEMENT		VERY LOW PROTECTION	SUBSTANDARD PROTECTION	STANDARD PROTECTION	ABOVE STANDARD PROTECTION	VERY HIGH PROTECTION
Degree of Passivity:	-2	-1	0	1	2	Degree of Protection:	-2	-1	0	1	2

References

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